RADIO BROADCAST

VOLUME XIII

MAY, 1928, to OCTOBER, 1928

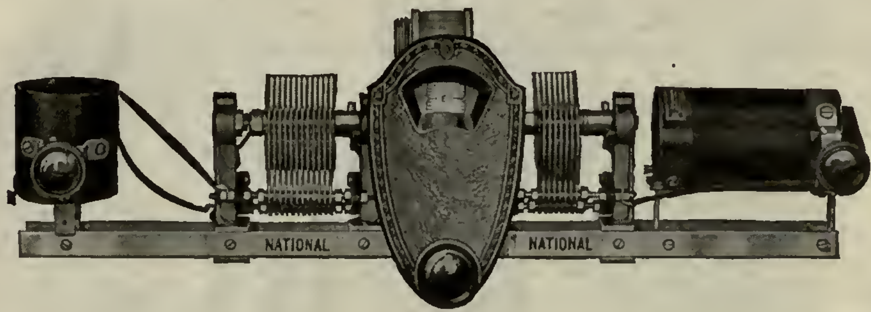
GARDEN CITY NEW YORK
DOUBLEDAY, DORAN & COMPANY, INC.
1928

INDEX

(*Illustrated Articles. Editorials in Italics)

NATIONAL

Single Dial Tuning-Unit - Type 222



Made expressly for experimentation with the new 4 electrode UX 222 tube. The newly designed transformer and variable induction antenna coil, NATIONAL Equitune Condensers and New NATIONAL Velvet Vernier Type F Single Drum Dial are mounted on rigid light aluminum girders that preserve the alignment. The unit is very easy to install and to use.

Volney D. Hurd, of the Christian Science Monitor, reports that on a test of this Type 222 Tuning Unit, at Malden, Mass., *Chicago stations came in like locals on a 5-foot antenna.* This means a DX-getting rating, under favorable conditions, of 200 miles per foot of antenna.

List Price, Type 222, $25.00

Two other types available. *Send for Bulletin 121-B.*

NATIONAL TUNING UNITS STANDARD WITH THE EXPERIMENTOR SINCE 1924

NATIONAL COMPANY INC · W · A · READY · PRES · SHERMAN · ABBOT · JACKSON STS · MALDEN · MASS ·

RESISTANCE *and* BRAKES

CLAROSTAT

Reg. U. S. Pat. Off.

RESISTANCE is to a radio circuit what brakes are to your car. You need good brakes. You vary them according to conditions. You apply them as required

Do the same with resistance. Use good reliable resistance. Vary your resistance according to requirements—circuit, components, voltage, signal, tubes, tube life and so on.

All of which spells Clarostat—a unique resistance adjustable to meet all conditions, and fixed when conditions have been met.

There is a Clarostat for every purpose—the tiny Volume Control for receiving circuits, Standard type for B-Power voltage control, Power type for heavy-duty units and electrified receivers, and Table type for use as an accessory with any set.

Ask your radio dealer to show you the complete line of Clarostats, and to give you informative literature on how to improve your radio. Or write us direct.

American Mechanical Laboratories
Incorporated
Specialists in Variable Resistors
285-7 N. Sixth St., Brooklyn, N. Y.

Learn Radio for Bigger Pay

GET into this new big-pay live-wire field. Its rapid, enormous growth has astounded the world. A flood of gold is pouring into this new business. Big and little fortunes are coming out of Radio every year. Trained men are needed. Opportunities in twenty different branches—Radio manufacturing, selling, servicing sets, in business for yourself, travelling all over the world without expense as an operator on board ship, operator in a broadcasting station, commercial land station operator and many other wonderful positions are explained in my 64-page book "Rich Rewards in Radio." Get a copy—clip the coupon—it's FREE. There's no obligation. Investigate!

Many Make $50 to $250 a Week

Why be satisfied with $20, $25, or $35 a week when the good Radio jobs pay $50 and all the way up to $250 a week and offer practically unlimited opportunities for quick financial progress. Study Radio now and in a short time land yourself a real job with a real future.

Easy to Learn at Home This Practical Way

Stay home. I'll train you in your spare time. My practical method, with six big outfits of Radio parts, makes learning at home in spare time easy, fascinating. You can build and experiment with practically every type of receiving set known. No other method can equal it. This course has put thousands of dollars in other fellows' pockets. High School education unnecessary. Boys 16, men up to 65 have mastered Radio this way. Your Money back if not satisfied upon completion.

Made $588 in One Month

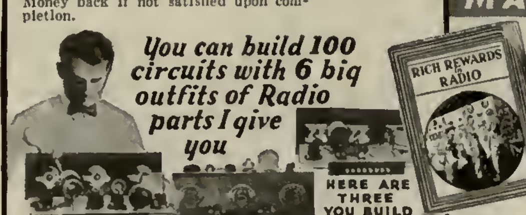
"The training I received from you has done me a world of good. Some time ago during one of our busy months I made $588. I am servicing all makes of Radio receiving sets. I haven't found anything so far that I could not handle alone. My boss is highly pleased with my work since I have been able to handle our entire output of sets here alone." Herbert Reese, 2215 South E. St., Elwood, Ind.

$10 to $30 a week in spare time while learning

That's what many of my students are making. Pay your tuition out of spare time earnings. This is the famous course that pays for itself. I show you how you can begin earning money almost the day you enroll. G. W. Page, 1807 21st Ave., Nashville, Tenn., writes: "I picked up $935, in my spare time while studying." K. W. Griffith, 2320 Maple St., Little Rock, Ark., made $894.

64-Page Book FREE

Send for it. Clip the coupon. It won't cost you a penny. It has pointed out the way to success to hundreds of fellows. See what Radio has to offer you and how my Employment Department helps graduates get good jobs. There's no obligation. Mail the coupon right now. Address: J. E. Smith, Pres., Dept. 5-O, National Radio Institute, Washington, D. C.



MAIL THIS COUPON

J. E. SMITH, President
Dept. 5-O, National Radio Institute
Washington, D. C.

Dear Mr. Smith: Without obligating me in any way, send me "Rich Rewards in Radio" giving facts and information on money-making opportunities in Radio and explaining your practical, fascinating way of teaching with Six Big Outfits of Radio Parts.

Name.......................................Age............

Address...

Occupation ....

Radio Broadcast. May, 1928. Published monthly. Vol. XIII, No. 1. Published at Garden City, N. Y. Subscription price $4.00 a year. Entered at the post office at Garden City, N. Y., as second class mail matter. Doubleday, Doran & Company, Inc., Garden City, N. Y.

RADIO BROADCAST

MAY, 1928

Willis Kingsley Wing, Editor

Keith Henney, Director of the Laboratory — Edgar H. Felix, Contributing Editor

Vol. XIII. No. 1

CONTENTS

The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

TO OUR READERS

BECAUSE we value very highly the confidence of our readers, we present here a few words about the editorial policy of this magazine as it affects the problem of editorial ethics. The readers of Radio Broadcast are much like the readers of a magazine devoted to book reviews. In the latter, editorial articles must deal, perforce, with the same subjects as found in the advertising pages. In Radio Broadcast our text pages must very often contain articles describing the use of units featured in the advertising pages. But how long would you read a book review publication if all reference to publisher, price and author were omitted? And how long would you read such a magazine if you felt there were collusion between editorial and advertising content?

ALL of the articles in this magazine—constructional ones, especially—are chosen for one reason, only, because we think they are interesting and useful to our readers. We are frank about mentioning parts employed because we believe our readers want to know that information. We have in the past and will continue to indicate in the future the possibilities of substitution of parts, leaving the actual construction to the judgment of the reader. The reader has a right to know just how any circuit we describe was built, what it costs, and whose parts are used. In Radio Broadcast, all this essential information is in the article. You will not have to write us for additional circuit diagrams, a list of parts or other essential information which should be in the article in the first place. Our duty to the reader is to give him articles which are interesting, useful, and *complete*. If he encounter difficulties, our Technical Information Service will help him by mail, and the editor will always be pleased to hear of the results he achieves.

THE technical accuracy of every statement made in this magazine is carefully checked by Radio Broadcast Laboratory, manned by radio engineers all of whom have technical university training. Their vigilance fortifies every article. Articles from the staff present material not available elsewhere, some of it constructional, some more general, but all with the definite purpose to be as sound and accurate as we know how. These requirements invariably apply to all our articles, whatever their source. Our Laboratory will continue to originate useful circuits of all sorts; contributions from independent radio workers are constantly sought and will regularly appear. Articles, constructional or otherwise, originating in manufacturers' laboratories will be published with their origin made quite clear, only when the articles meet our rigid requirements. This is and has been our practical conception of responsibility to the reader.

THE news of radio developments, no matter where they originate, is important, so, naturally, the activities of radio manufacturers will be reported in these pages, but no such articles have appeared or will appear merely because of their advertising potentialities. The reader need not fear that this magazine will overflow with articles thinly masking manufacturers' publicity. Is it good? Is it useful? Is it important?—those questions must be satisfactorily answered before the article appears in our pages, whether or not the article originates with a manufacturer. It is only natural if readers respect our text pages that the advertiser should find our advertising pages valuable, and it is obvious that no publication can long exist without high standards in both editorial and advertising content.

—Willis Kingsley Wing.

DOUBLEDAY, DORAN & COMPANY, INC., Garden City, New York

MAGAZINES

Country Life
World's Work
Garden & Home Builder
Radio Broadcast
Short Stories
Educational Review
Le Petit Journal
El Eco
Frontier Stories
West
The American Sketch

BOOK SHOPS (Books of all Publishers)

New York: Lord & Taylor; James McCreery & Company; Pennsylvania Terminal and 166 West 32nd St.; 848 Madison Ave. and 51 East 44th Street; 420 and 526 and 819 Lexington Avenue; Grand Central Terminal and 38 Wall Street
Chicago: 75 East Adams Street
St. Louis: 223 N. 8th St. and 4914 Maryland Ave.
Kansas City: 920 Grand Ave. and 206 West 47th St.
Cleveland: Higbee Company
Springfield, Mass: Meekins, Packard & Wheat

OFFICES

Garden City, N. Y.
New York: 244 Madison Avenue
Boston: Park Square Building
Chicago: Peoples Gas Building
Santa Barbara, Cal.
London: Wm. Heinemann, Ltd.
Toronto: Oxford University Press

OFFICERS

F. N. Doubleday, *Chairman of the Board*
Nelson Doubleday, *President*
George H. Doran, *Vice-President*
S. A. Everitt, *Vice-President*
Russell Doubleday, *Secretary*
John J. Hessian, Treasurer
Lillian A. Comstock, *Ass't Secretary*
L. J. McNaughton, *Ass't Treasurer*

TERMS: $4.00 a year; single copies 35 cents.

VITROHM RESISTORS . IN EVERY INDUSTRY . IN EVERY LAND

Vitrohm Resistor 508-2 is employed by the Thordarson Electric Mfg. Co. in their R210 Power Compact. The Resistor has a total resistance of 13,000 ohms in steps of 2000, 2000, 2000 and 7000 ohms. It is priced at $2.65.

Vitrohm Resistors for radio

¶ Vitrohm Resistors are made by winding a special resistance wire upon a refractory tube and protecting both the wire and terminal contacts with fused-on vitreous enamel. This process has been used by Ward Leonard Electric Co. for more than 36 years.

¶ *Circular 507*, describing Vitrohm Radio Resistors, and "*Vitrohm News*" will be sent you without charge upon request.

. . . . *Equipped with*

VITROHM RESISTORS

TODAY'S electric radio receiver is a highly complex instrument placed at your service by the throw of a switch and turn of a dial.

The intricacies of circuit and mechanical design probably do not interest you; it is enough that the receiver operates to your satisfaction each time it is turned "on".

One criterion of probable receiver life is the quality of component parts. The resistors, for example, limit current and voltage in almost every part making up the receiver. Their failure frequently means damage to other parts.

Vitrohm Resistors are most frequently chosen by those radio manufacturers who make certain that their product will serve you long and well.

Vitrohm Resistors are chosen by every industry where the accurate control of current and voltage over an indefinite life is of importance. Make certain that the power supply unit in your next electric radio receiver employs them.

WARD LEONARD ELECTRIC CO.

MOUNT VERNON, N.Y.

38-32-33-3

Radio Service in a Philadelphia Hotel

THE Hotel Robert Morris in Philadelphia, in common with many other hotels in the United States, has provided its guests with a compelling reason to stay in their rooms in the evening The Robert Morris was equipped in March, 1925, and the unusual feature of the arrangement is that the widest possible program choice is offered to the listener. A plug with three jacks is provided in every room and the three jacks provide the program at the moment being transmitted over the Blue or Red Networks of the National Broadcasting Company or the Columbia chain. The radio control room is located on the top floor of the hotel and the equipment, in the main office on the first floor, is operated by remote control. Constant volume level throughout the hotel is maintained by using compensating and repeating coils. By grouping the jacks in the various rooms in parallel series it is possible to maintain reception in every room in the hotel even though trouble develop in the outlet in one or more rooms.

WHIPPANY

Will New Transmitting Methods Be the Remedy?

By Edgar H. Felix

THE acuteness of the broadcasting congestion problem focusses public attention upon any method suggested to increase the capacity of the broadcasting band. Many proposals have been made, some of which hold promise and others which, if put into practice, would only increase the existing confusion. Since the regulation of broadcasting has become a political matter, the great danger exists that the statements of pseudo-scientists may be accepted and untried plans for station synchronization will be forced into practice before they have been fully developed.

There are only two possible ways of reducing congestion in the broadcast band: (1), large numbers of stations must be eliminated, reduced to part time, or curtailed in power, or (2), the number of stations of a given power, successfully occupying the same channel, must be increased. Time division is already practiced to such an extent that further relief cannot be expected from this source without too much restriction of the service and earning power of existing stations. Power reduction will only lessen the value of better stations; the tendency is toward increased power because it means better program service for greater numbers. Legal and political considerations make it impossible to expect wholesale station elimination as a source of the radical improvement necessary for good broadcasting service in every section of the country.

Consequently, the only measure of relief which can be effective is the development of some means of increasing the number of stations of present powers operating on the same channel without interference. Many schemes to effect this result have been offered. They fall into three classifications:

(1) The elimination of the carrier whistle by accurate control of the carrier frequency of stations occupying the same channel, permitting service range rather than carrier range to determine the necessary spacing between stations on the same channel;
(2) The synchronization of both carrier and program, popularly referred to as placing chain stations on a single channel;
(3) The limitation of the carrier range to the service range of the station by the application of new principles of transmission.

Before considering in detail the actual methods for each of these general systems, what are the requirements for a plan which will increase the capacity of the broadcasting band? Four major qualifications must be met and failure to meet any one of them condemns any suggestion as useless. They are:

(1) The system must be of unfailing reliability in operation. The adoption of closer spacing among stations on the same channel, the objective of most of the systems,

Service Range and Interference Range

THE following table shows how the power radiated by a broadcasting station affects, (a) the "service range," which is that distance over which good reception will be possible independent of static, day and night, rain or shine; and (b) the "interference range," which is that distance over which the carrier wave of a broadcasting station can mar reception by generating a heterodyne whistle with the carrier wave of another station:

	Miles		
Antenna Power in Watts	Satisfactory Service	High-Grade Service	Carrier Interference Range
5	10	1	100
50	22.5	3	250
500	65	10	625
5000	160	30	1500
50,000	350	90	3000

If we divide the interference range by the high-grade service range we get the following figures:

Antenna Power in Watts	Interference Range Divided by High-grade Service Range
5	100
50	83
500	62.5
5000	50
50,000	33

The figures in the right-hand column show clearly that high-power stations approach closer to the ideal condition as the ratio of the interference range to the service range is decreased.

means that their temporary or permanent failure will bring heterodyne whistles of much greater intensity than are experienced under present conditions.

(2) The system must not demand an order of operating skill beyond that obtainable by average broadcasting station staffs.

(3) The first cost of equipment required and its maintenance expense must not be so high as to place it beyond the financial capacity of average broadcasting stations.

(4) The adoption of the system must not require any substantial alteration in transmitting and receiving equipment and must entail no sacrifice in quality of reproduction.

We will examine each proposal in the light of these four qualifications. The first general class of methods concerns those intended to eliminate the carrier heterodyne or whistling interference with which all listeners are now painfully familiar. The pitch of the carrier whistle depends upon the difference in frequency between the two or more carriers simultaneously actuating the receiving set. Suppose we have two stations assigned to a million cycles, or 300 meters, one precisely on the assigned frequency; the other one half of one per cent. above it, or on 1,005,000 cycles. The resultant effect will be to impose a 5000-cycle note upon the programs of both stations. If one station deviates a hundredth of 1 per cent. from the assigned frequency, the resultant heterodyne will be a hundred cycles. Accuracy of one part in a hundred thousand is therefore essential if the carrier heterodyne is to be reduced to a point below audibility. In that case, the maximum heterodyne note would be 20 cycles, assuming that both stations have deviated in opposite directions from the assigned frequency. Note the extraordinary stability necessary to permit two carriers to overlap without heterodyne.

The intensity of the whistle heard at a receiving point is dependent upon the *carrier energy* received from the more distant station. The degree to which it mars reception depends somewhat upon the ratio of the carrier whistle to the amount of *modulation* received from the nearer station. An understanding of these two statements will reveal why carrier synchronization will effec real relief under present conditions. You have frequently heard a heterodyne of considerable intensity and waited for the local station to sign off, in the hope that you could identify the distant station causing the whistle. But you find it impossible to hear the slightest sound from the distant station. This is due to the fact that the carrier spreads from thirty to forty times the distance that a high-grade program signal is heard and also, because of the square law operation of the detector tube, the carrier is subject to much greater amplification than the audio-frequency modulation impressed on it

WHY STATIONS ARE SPACED

IN PRACTICE, this condition accounts for the great spacing required between stations of moderate power, if the service area of each of them is to enjoy undisturbed reception. The maximum high-grade service range of a 500-watt station is 30 miles, but its average carrier range is at least 1000 miles and often over 2000 miles. Under average conditions, it delivers a distinguishable program signal to sensitive receivers for perhaps 350 or 400 miles. If two stations on the same channel are perfectly synchronized, they would have to be spaced only 400 to 500 miles apart, without suffering audio-frequency distortion within their respective local service ranges. But, under present conditions, 1500-mile separation is necessary to reduce carrier heterodyne to the point that local reception is not noticeably affected and complaints are often registered with respect to heterodynes caused by 500-watt stations 2000 miles distant from the receiving point.

"SERVICE AREA" AND "INTERFERENCE RANGE"

The circles show the relative areas of high-grade service range, satisfactory service range, and interference range, of a 50,000-watt broadcasting station. Note how large the interference range is in comparison to the service range. The actual service area of this station does not extend beyond the area enclosed by circle No. 2, for at greater distances, static and fading will interfere with good reception. The much larger area of circle No. 3 extends far beyond the area of fair reception. Within this large area the station can create interference by generating a heterodyne with the carrier wave of another station, supposedly operating on the same frequency, but actually transmitting on a frequency slightly higher or lower. Accurate stabilization of the carrier frequencies of stations operating on similar frequencies—perhaps by the quartz crystal method—will prevent heterodyne interference but will not prevent interference arising from the clashing of sidebands

Four methods have been suggested for stabilizing the carriers of broadcasting stations so as to eliminate the possibility of carrier whistle:

(1) Stable precision crystal oscillators;
(2) Remote manual control of carrier frequency;
(3) Radio transmission of a reference frequency; and
(4) Wire synchronization of carriers.

The zero-beat method, employing crystal control oscillators, is now widely used. The station operator wears a headphone through which courses the output of the crystal oscillator and also the station's radiated carrier frequency. The frequency of the station is adjusted until the two are in exact synchronism so that no heterodyne whistle is heard.

In preparing to write this article, the author maintained a broadcasting station on its frequency by the zero-beat method for several programs. When utilizing a crystal oscillator, installed at the station, the comparison signal is constant and powerful. The amount of skill required and the cost of maintenance of the equipment needed are within the reach of any broadcasting station.

Independent crystal control, however, has been described as too inaccurate and too unstable to permit the perfect synchronization of two carriers. As a matter of fact, there is no inherent fault in the crystal oscillator which cannot be corrected. What are needed are perfected means of supplying crystal oscillators with absolutely constant voltages and means of maintaining the crystal at an absolutely constant temperature.

A change of one degree centigrade varies the frequency of a crystal oscillator by sixty to a hundred cycles. The crystal oscillator is usually installed in a penthouse on the roof of a building where the transmitter is installed. Heat supply is often uncertain in such exposed locations and temperature variations of twenty degrees, during operating hours, are not uncommon. Such a change is sufficient to cause a 2000-cycle variation in the frequency of a crystal oscillator.

Crystals have been submitted to laboratories by broadcasting station owners with a view to finding out why they do not hold the station to its assigned frequency. Among these are ordinary quartz lenses, crudely scratched and insecurely mounted in contacting clamps. These worse-than-useless crystals have been sold to broadcasting stations with the expectation that they will stabilize carrier frequencies. The fact that a station uses crystal control is no guarantee whatever that it will remain accurately on its frequency any more than providing an aviator with a compass assures that he will arrive safely at a distant destination.

Proponents of the crystal oscillator method have sometimes proved their case by setting up two such oscillators in the laboratory, both using a slab from the same quartz crystal. Such demonstrations, however, prove nothing because both oscillators are then working under exactly the same conditions. When one of the oscillators is shipped to a distant station to control its carrier, varying temperature conditions cause sufficient deviation to produce annoying heterodynes. With equipment now commercially available, the crystal oscillator does not possess sufficient stability to eliminate the heterodyne whistle between two stations operating on the same channel. Nevertheless, development of precision oscillators, with accurate temperature control, is a most promising line of research.

MANUAL CONTROL OF FREQUENCY

A NUMBER of enthusiasts have loudly heralded their success in synchronizing their station's carrier with a single interfering station by checking the heterodyne with a receiving set remote from the broadcasting station. This is the second method listed. By means of a wire connection with the station, the carrier frequency is varied until the observed heterodyne

disappears. Because, in isolated instances, two stations have employed this method successfully, it has been hailed as a panacea. In those cases where two stations, assigned to the same channel, cause a heterodyne sufficiently loud to permit of easy elimination by the zero-beat method, they both suffer audio-frequency distortion, due to the interaction of their programs, even within their immediate service areas.

Although the heterodyne whistle may be eliminated, the system does not permit of accurate synchronization unless the receivers used respond to frequencies below sixty cycles. Furthermore, the scheme merely accomplishes approximate synchronization between two stations and affords no assurance that either station is on its assigned frequency. Should any number of stations on the same channel use this plan, that frequency would become a raving bedlam, each station trying to follow the others, each not knowing what changes to expect in the frequency of the others. The difficulties of manual frequency control can best be appreciated by setting up three or four regenerative receivers in neighboring houses, adjusting them all in an oscillating condition upon a predetermined broadcasting station, and maintaining them there without permitting an audible whistle.

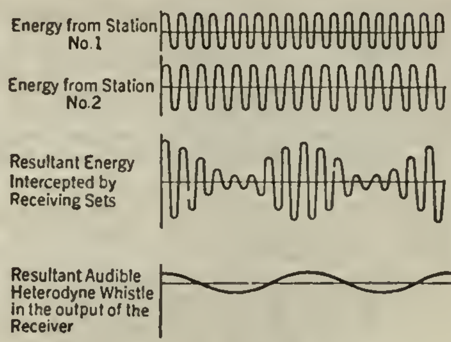
The third plan listed is theoretically most attractive. A short-wave station is to radiate a national synchronizing signal, to be used as a reference frequency by all broadcasting stations. This is accomplished by radiating a 10,000-cycle note, impressed by modulation on a short-wave carrier. A receiving set, installed at each broadcasting station, would pick up this signal, supply it to a harmonic producer which multiplies the received note to the assigned frequency of the station. The station's carrier would then be adjusted until it zero-beat with the output frequency of the harmonic producer. The transmitted synchronizing signal cannot be higher than 10,000 cycles because it must be a multiple of every frequency used as a broadcast carrier.

The manual control of a broadcasting station's frequency is difficult enough when a local crystal oscillator at the station itself furnishes the reference frequency. But to use for this purpose a weak and varying national synchronizing signal, transmitted in most cases more than a third of the way across the country, is like trying to balance an egg on your nose. The carrier frequency of a broadcasting station is constantly subject to slight variations, due to changing temperatures of vacuum tubes, voltage changes in the main power supply, and the effect of modulation peaks. Each of these variations must be compensated by readjustment of the carrier frequency. The source of the reference or comparison frequency must therefore be perfectly stable.

A NATIONAL SYNCHRONIZING SIGNAL?

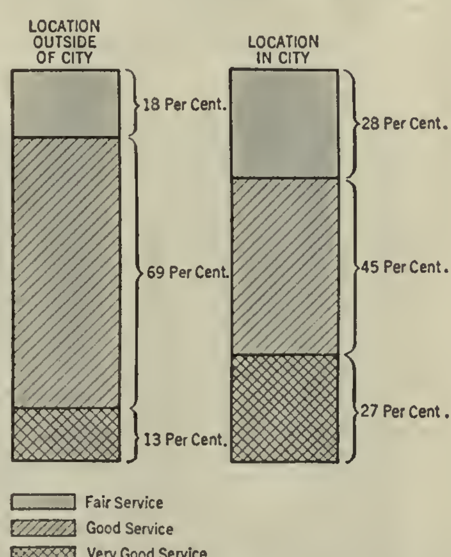
THE principal difficulty with the national synchronizing signal plan is that the entire country cannot be successfully blanketed by the output of a single short-wave station at all hours of the day and night. The received signal must be sufficiently strong and stable to actuate a harmonic producer and produce a steady reference frequency for every broadcasting station in the United States. The system does not meet the requirement of reliability. The cost of maintaining a national synchronizing station in continuous operation, even if divided among 700 broadcasters, and the rather elaborate receiving equipment needed at each station is a serious, though by no means insurmountable, barrier to the plan.

The fourth method is the employment of wire lines for synchronizing stations. In the case of chain broadcasters, it might be possible to use the order wire circuit interconnecting chains, but, since chain circuits are set up for only an hour or two each evening, the contribution to stability which this would afford is quite negligible. There are not enough telephone wire facilities to spread a national synchronizing signal to every city where a station exists. The cost of interconnecting hundreds of stations would run into several million dollars annually. The economic burden which wire synchronization on a national scale would impose is entirely beyond the capacity of the broadcasting industry to bear.



WHEN TWO STATIONS INTERFERE

Station 1 may be operating on its correct frequency, but Station 2, which we will assume should be on the same frequency, may be slightly off its assigned frequency. A receiver tuned to Station 1 also receives energy from Station 2. The third curve shows what happens in the detector circuit: the two waves combine and in the loud speaker there is a heterodyne whistle, constant in pitch, indicated by the fourth curve. If the whistle is loud enough, it will completely ruin reception. Accurate stabilization of the carrier frequencies of all broadcasting stations within an accuracy of at least .05 per cent. is absolutely essential if reception is to be free of heterodyne interference due to this cause



STATIONS SHOULD BE OUTSIDE CITIES

The drawings show the relative effectiveness of two transmitters of equal power, one located in a city and the other outside. As many listeners as possible should be included within the good service area of a station, which is possible by locating the station outside of a city. Under such conditions, 69 per cent. are located in the area of good service compared with 45 per cent. in the previous city location. Locating a station outside of a city distributes more evenly the field strength of the signals because the absorption effect of steel buildings is removed. (Data from *Bell System Technical Journal*, Jan. 1927)

With respect to the second problem, the synchronization of both program and carriers on the part of chain stations, many of the considerations already discussed apply. The outstanding example of carrier and program synchronization has been the successful simultaneous operation of WBZ in Springfield, Massachusetts, and WBZA in Boston. A special channel is utilized to transmit a synchronizing signal so that both stations take their carrier frequency from the same frequency source. Both stations invariably broadcast the same program. The results of this experiment have been satisfactory and the question is often asked why all the stations of the Red Network, for instance, do not synchronize their carrier frequencies in the same way so that, instead of occupying ten or twelve channels, they would use but one.

The task of carrier and program synchronization of WEAF and WLW, for example, as compared with the synchronization of WBZ and WBZA, presents some curious problems, the importance of which is not generally realized. In the first place, WBZ and WBZA are separated by only seventy miles, while WEAF and WLW are 570 miles apart. This eight-folds the wire leasing costs for synchronizing the latter two stations, making a truly imposing financial burden. Secondly, the two stations do not continuously and invariably radiate the same program. Were they to radiate two *different* programs, audio-frequency distortion of both programs would be sufficient to cripple the entertainment value of both stations, even well within their local service areas. Third, since large areas receive signals from both WEAF and WLW in appreciable amounts, the received signals in such areas would cause phase distortion. The reason that phase distortion is not experienced more generally in the WBZ-WBZA combination is that, because of an inexplicable ether wall, there are few points where an appreciable signal is received from both stations.

Considering that radio waves travel 186,000 miles a second, it is hard to conceive appreciable lag in the reception of the same program radiated simultaneously from two different stations at varying distances from a receiving point. But, even in the hypothetical case of WEAF and WLW this lag may cause serious distortion. A listener at Staunton, Virginia, where both WEAF and WLW are received with good volume, is approximately 272 miles from Cincinnati and 365 miles from Bellmore. The distance from Bellmore is 93 miles greater than the distance from Cincinnati and therefore, theoretically at least, the program from Bellmore would lag $\frac{1}{500}$ of a second behind that from Cincinnati. This would cause serious distortion. Some frequencies in the musical scale would be exaggerated and others reduced in intensity.

Experience with the reception of several signals from the same station, through the effect of reflection and the influence of bodies of water resulting in phase differences, offers valuable evidence, tending to confirm the distorting effect of synchronized chain broadcasting where the receiver responds appreciably to signals from more than one broadcasting station.

Ordinarily, the reception of two or three signals from the same station does not seriously affect quality because one of the signal sources usually predominates over the others sufficiently to make their influence negligible. But there are many known cases where phase distortion accounts for the poor quality with which high-grade stations are heard in some areas. When WEAF broadcast from Walker Street, several years ago, listeners in Pelham, New York, but 16 miles airline distance from the transmitter, complained that, even with the best of receivers,

only a weak and distorted signal could be received. A thorough investigation with loop receivers and field strength measuring equipment revealed that two signals from WEAF, apparently coming in from two different directions and, at some points, exactly 180 degrees out of phase, tended to cancel each other. Similar effects would be experienced when two stations radiate identical programs on the same channel.

If a chain of twenty stations were synchronized, the resultant reception, at all points beyond the high-grade service range of the synchronizing stations, would at least lack that clearness and purity of tone which characterizes modern broadcasting and might be sufficiently confused to be almost unrecognizable. Because of this consideration, desirable synchronization of chain programs is limited to stations widely separated geographically so that no listener is within the practical range of more than one synchronized station.

CHAIN STATION SYNCHRONISM

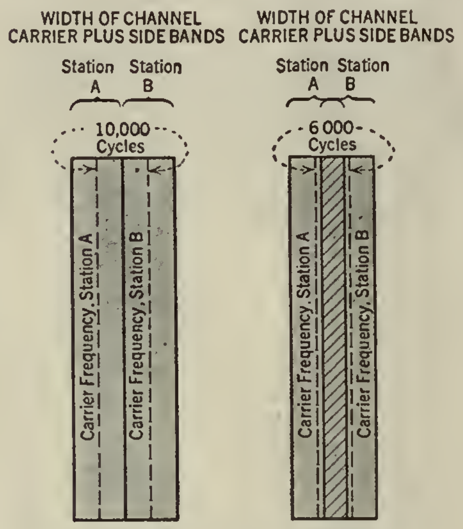
THE practical application of synchronization of chains is thereby limited to the establishment of two or three groupings per chain rather than placing all the members of a chain on a single channel. This would not effect radical saving of cleared channels, a maximum of four or five for each chain being possible.

A further barrier to extended chain synchronization is the fact that it can conserve channels only if the stations involved broadcast chain programs exclusively. Since most of the subscribing stations use chain programs only occasionally, an hour or two each evening at the most, permanent assignments to synchronized channels is now impossible. The cost of wire lines and chain features is altogether too high to require subscribers to chain programs to utilize only chain programs. Yet, only under those conditions, would chain synchronization effect any economy of channels. Most chain stations broadcast local programs and perform local services during a majority of their broadcasting time. These services would have to be discontinued or transferred to minor stations under any plan of widespread chain program synchronization.

Considering that the problem is to find comfortable room for nearly 700 stations in a band of 89 channels, reliance upon the single measure of chain station synchronization does not offer any promise of real relief, even if the difficulties cited could be overcome immediately.

A trend of development which holds some promise is improvement in the permissible percentage of modulation without resultant distortion. This is the third general measure of relief given at the beginning of this article. Its effect is to increase the percentage of the high-grade service area to the total carrier interference range area. The experimental fifty-kilowatt transmitter at Whippany, maintained by the Bell Laboratories, utilizes a new method of combining carrier with program signal, said to effect one hundred per cent. modulation. While the results, so far as increased service range for a given carrier power is concerned, are not startling, they are, nevertheless, appreciable. The engineering ideal to be attained in this direction is that the carrier shall cease to radiate at the edge of the station's high-grade service area. The problem of setting up an intense wave motion of any kind and making it cease abruptly at the limit of its usefulness is a tremendous challenge to engineering ingenuity. In radio transmission, there is room for so much improvement in reducing the ratio of carrier spread to useful service range that some progress in this direction may be hoped for. But that this development will have material bearing in the present situation is not within the expectation of the most sanguine workers in this field of research.

Considering the immediate possibilities of all the proposed measures of relief, none holds greater promise than the development of high-precision crystal oscillators with accurate temperature control. Realizing the value of a source of constant-frequency oscillation, many laboratories have been concentrating on this problem during the last few months. The writer has seen, in the development stage, a new type of quartz crystal precision oscillator for broadcasting stations which will probably be marketed by the R. C. A. This device will consist of two accurately ground and matched quartz crystals mounted in a constant temperature chamber. The temperature is kept constant by means of a thermostat and maintained at a given setting



"CARRIERS" AND "SIDEBANDS"

Stations assigned to adjacent broadcasting channels transmit on carrier frequencies differing by 10,000 cycles. When programs are transmitted, two sidebands are produced which introduce into the transmitted wave, frequencies up to 5000 cycles above and 5000 cycles below the carrier frequency; the station therefore uses a band of frequencies 10,000 cycles wide. The left sketch shows the frequency bands used by two adjoining stations. The two carrier frequencies differ by 10,000 cycles; the sidebands meet each other but do not overlap. This holds true when two adjacent stations hold exactly to their assigned frequency. If either station varies, the condition shown at the right obtains, where we have assumed that one station has wandered from its frequency to the extent of 4000 cycles (4 kc.) deviation. This leaves the carrier separation between the two only 6000 cycles (6 kc.). Then, in the receiver output, we would hear a 6000-cycle note, which may be loud enough to ruin reception. Interaction between the two sidebands of the stations—shown on the shaded portion of the diagram—also occurs

by means of this thermostat, checked by a thermometer. A suitable heating coil is also mounted in the constant temperature chamber. The two crystals, supplied with this oscillator, may be ground to any one frequency in the band of from 550 to 1500 kilocycles. A small selector switch is arranged to select either of the two crystals. Should one of the crystals fail during the operation of a broadcasting station, it is only necessary to throw this selector switch which removes the defective crystal and cuts in the spare crystal, which will be at the right temperature to start operation immediately.

The oscillator circuit will consist of a vacuum tube and coil system, the electrical constants of which have been very carefully determined with a view to being suitable to work with the quartz crystals. A monitoring receiver, comprising a suitable detector and two stages of audio-frequency amplification, in a separate box, has also been designed for use in connection with the quartz crystal precision oscillator. When these two boxes (the quartz crystal oscillator and the monitoring receiver) are used in conjunction, a loud speaker may be connected to the output of the last stage of audio-frequency amplification and the quartz crystal frequency beat against the carrier of the broadcasting station. Special precautions will be taken to emphasize the low frequencies so that the zero-beat note will be heard at its greatest efficiency.

No definite claims have yet been made as to the stability of this device, but there is no question that two stations, operating on the same channel, both employing the device, will not heterodyne each other seriously. It should eliminate the high pitched squeal and that, alone, will justify its installation. It is not unreasonable to expect that, with continued improvement and experience with precision quartz crystal oscillators, complete carrier synchronization will ultimately be made possible.

NEW METHODS OF TRANSMISSION

THIS summary would be incomplete if mention were not made of several proposed new methods of transmission, claimed to reduce the width of the channel required by a broadcasting station. These methods are frequently mentioned in public statements, issued as possible measures of relief by persons who must know the objections to their adoption in the broadcast band. One is single side-band transmission, accomplished by suppression of the carrier and one side-band, as utilized in practice in the transatlantic telephone. It has the vital objection that its adoption is predicated upon scrapping every transmitting and receiving equipment in the country. The broadcast receiver necessary to pick up single side-band transmission is expensive and delicate. One of its elements is an oscillator which must be adjusted to within ten or fifteen cycles of the assigned frequency of the station to be received, in order to supply the missing suppressed carrier. To reëquip every broadcast listener with a suitable receiver under this system would cost the public not less than half a billion dollars.

Another suggestion along these lines is the adoption of a new system of frequency modulation. For this has been claimed the extraordinary virtue of accommodating simultaneously between one and two thousand broadcasting stations in the present band. The basic principle of the system is that the carrier frequency is shifted up and down according to the desired audio signal to be transmitted. The receiving set is tuned with extreme sharpness so that the shifting carrier causes varying energy to actuate the receiving set by reason of the detuning effect. This sytem would also require the scrapping of all receiving sets, unless the carrier is shifted over so wide a scale that no economy of channels is effected. The contention is also raised that a shifting carrier sets up numerous harmonics so that the theoretically narrow band occupied by the frequency modulated carrier would prove to be in practice no narrower than that used by broadcasting stations operating under the present simple methods of modulation.

A most exhaustive study of the entire subject will lead inevitably to the conclusion that progress in increasing the capacity of the broadcasting band will be steady but that no radical developments, sufficient to offer a complete solution to the present problem, are in sight.

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

Why the Persistent Cry of Monoply?

THE struggle now shaking the foundations of the radio industry has long been brewing. On one hand is assembled a group of militant independent manufacturers, vigorously attacking an alleged monopoly whose grasping tentacles reach into every branch of the radio field; on the other hand, the radio mouthpiece of vast electrical interests, claiming, with injured innocence, that it was born out of patriotic motives and possesses its imperalistic power over the radio industry by virtue of its widespread and proper patent rights. Drawn into this conflict are the Federal Courts, the Federal Trade Commission, Congress, and the Federal Radio Commission.

The consequences of this struggle may be far-reaching. So great is the patent strength of the combination that little reliance is placed upon upsetting the validity of enough patents which it holds to free the industry of its domination. Nor is there any vast sum being spent in research to develop non-infringing vacuum tubes and associated circuits. Instead, attack has been made upon the methods used in taking advantage of its patent position and upon the fundamentals of the patent itself.

Several bills before Congress propose drastic revision in the powers conferred upon all patent holders; one, for example, seeks to make revocation of patents the penalty for violation of anti-trust laws so that companies conducting research and promoting progress will suffer more severely than those which simply copy designs and infringe patents. Another bill proposes that patents applying to vacuum tubes shall not confer upon their holders the same rights which apply to all other articles, a plain discrimination against one industry.

Another line of attack is through the Federal Radio Commission. The commission is severely criticized by Congress, to which it reports, and by hostile station owners, for the privileges extended to the chain stations, partly owned by the combination. Bills proposing equal geographic distribution of broadcast transmitters are being written, requiring the destruction or curtailment of useful and popular broadcasting services. The operation of such a law would inevitably require power reductions on the part of WEAF, WJZ, WGY, and KDKA, all N. B. C. stations. No avenue is being overlooked to injure, directly or indirectly, any and every activity of the combination.

Let us view the situation sanely. A wave of resentment has arisen against the power of the Radio Corporation of America and the huge electrical interests backing it. This power is based upon the ownership of patents, in themselves a legal monopoly. The restrictions imposed by patent holders are escaped either by abandoning the field, paying royalties, or devising new methods which do not infringe. Many companies in the radio industry have elected to pay royalties. There is no indication that any of the unlicensed independents are making any real effort to devise non-infringing designs. They elect to follow none of the three customary alternatives.

Politics have further clouded matters in a fog of flaming oratory. Bills are proposed, with the intention of injuring the Radio Corporation of America, which, if passed, will accomplish that objective, but will also mutilate both the present broadcasting structure and the entire patent structure upon which American industry has been built. The Radio Corporation of America should be punished for any crimes of which it is guilty, but it would be unfortunate if unwise legislation were enacted in the current anxiety to inflict punishment.

The foundations for the present situation were laid shortly after the war. American communications had been greatly hampered, both during and after the period of neutrality, by foreign censorship and foreign ownership of cables and long-distance radio communications. Naval officials desired the establishment of an American owned transoceanic network and an American radio industry so that channels of communication and sources of supply for war needs would always be available. No one company had access to a sufficient number of patents to enable it to conduct a profitable transoceanic radio service or even to manufacture modern vacuum-tube transmitting and receiving apparatus.

With the encouragement of high naval officials, the Radio Corporation of America was formed in 1919. It was given rights, in a patent pool comprising the principal radio patent holders, to conduct transoceanic services and marine communication and also to sell transmitting and receiving apparatus to the handful of amateurs then operating. The pool consisted of the American Telephone & Telegraph Company and its subsidiary, the Western Electric Company, the General Electric Company, the Westinghouse Electric & Manufacturing Company, and the Wireless Specialty Apparatus Company. Each company threw their radio patents into the pool and received license under *all* the patents, each for use in a particular and limited field of activity. The fundamental objective of the combination sought by the Navy was promptly accomplished. The world-wide communication system came into being. Had this been the only result of this pooling arrangement, there would be no conflict to-day.

RADIOMARINE CORPORATION ORGANIZED

The ship-to-shore marine radio communications of the Radio Corporation of America were transferred to a new subsidiary, the Radiomarine Corporation with which was combined the Independent Wireless Company. Charles J. Pannill, former president of the Independent, is now vice-president and general manager of Radiomarine and J. P. Duffy, for years superintendent of the New York division of RCA marine, has been appointed superintendent of operations. Mr. Duffy is shown above

Radio broadcasting came in an avalanche of public enthusiasm in 1920 and 1921. It is obvious to anyone who has read the original agreement, upon which the patent pool is based, that broadcasting was not contemplated when the pool was formed. But the patent structure which was thus built up has established an almost impregnable domination of the radio industry. Considering the immense research facilities of the group and the important patents which its various members have purchased, it is in a position to maintain that hold, unless its patent rights are abridged or modified.

At the beginning of the radio boom seven years ago, few of the group's radio patents had been adjudicated. An independent industry grew up and flourished in total disregard of these patents. A few gestures were made by the group to make known its patent holdings, such as sending infringement warnings to manufacturers by registered mail regarding the Pickard crystal patents, but no effort was made to make the public conscious of the importance of the pool, its research facilities, and the patents which it held. Suits were filed which are only now being finally settled.

With recent adjudications, all of the large producers, representing about three fourths of the industry's volume, have become licensees of the group. The remainder have been unable or unwilling to meet the license terms, with their minimum annual royalty guarantee of $100,000. The independent vacuum-tube industry has been virtually destroyed by the effects of one of the clauses of the license contract which requires that all licensed radio sets be equipped with tubes sold by the R. C. A. or Cunningham, a subsidiary. This clause has been adjudged as a case of restraint of trade under the Clayton Act. The R. C. A.'s justification might be among other things, that no one can make tubes without infringing their patents (adjudicated and unadjudicated), and hence there is no legal competition.

This, briefly, and stripped of many ramifications, is the background of the situation. The combination was formed with a useful and patriotic purpose which has been successfully accomplished. Its existence was also instrumental in initiating the first permanent broadcasting and, more recently, in making possible a source of a comprehensive license to manufacture radio receiving sets without infringement of any but a few patents held outside of the group. Several members of the combination are responsible for vitally important research work, contributing to the modern standard of radio reproduction.

Strong companies and dominent groups exist in

every important field of industry. But in none is the dominant group so generally disliked and so freely criticized. Mention of the General Motors to an independent automotive engineer or motor car wholesaler does not have the effect of ruining his digestion or moving him to profanity. Why all this resentment against the radio combination?

The Radio Corporation of America is singularly devoid of public relations sense. It has never effectively set itself to the task of winning public goodwill. Only when under attack does it offer belated explanations. It conducts its affairs in a dictatorial manner, deciding for itself what is good for it and what is good for the entire industry. It regards the interests, but apparently not the opinion, of the public. The severest penalties are imposed by the court of public opinion.

We must distinguish between publicity and public relations. Publicity is a matter of releasing information to the press. In this respect the R. C. A. is highly efficient. It issues publicity material copiously. Public relations involve every relationship with those outside a company's personnel, not merely relations with the press. The building up of satisfactory public relations requires that every act, however small, be considered in the light of public understanding and interpretation.

It may be legal to collect royalties based on the gross business of a licensee, but how will the public react to the knowledge that one manufacturer, making a cheap table model radio set, pays three or four dollars royalty on each set he makes, while another, using the same patents in the same way, pays fifteen or twenty dollars because his set is of high quality and is housed in a piece of fine furniture? How will the public feel when it learns that R. C. A. patent royalties have been sufficiently large to add greatly to the cost of producing radio sets and to make the operations of some of the most successful independent companies almost profitless?

An early adjustment of the present situation must be effected, lest it cause the passage of legislation detrimental to all patent holders. Any law which makes a patent less valuable and offers less protection to the owner of a patent will discourage scientific research and rob the independent inventor of his incentive to devote himself to progress. Unless considerable forbearance and cool judgment is displayed by all the parties involved in the present controversy, the only possible outcome is legislation which will permanently weaken our patent structure. Aroused public opinion may exact too great a penalty, unless the patent holding group be guided by more of the spirit of live and let live.

Radio Laughs at Wired Wireless

OUR contemporary, *Radio Retailing*, leads off, in a recent issue, with a stirring editorial to the effect that the radio industry can no longer "laugh off" the approach of wired wireless. It states that the program services, which the electric companies will soon pour into American homes via the power lines, will be superior in quality to "space" broadcasting and hints that radio will have difficulty in competing with them. The publication solemnly warns the radio industry to prepare for the competition of wired wireless.

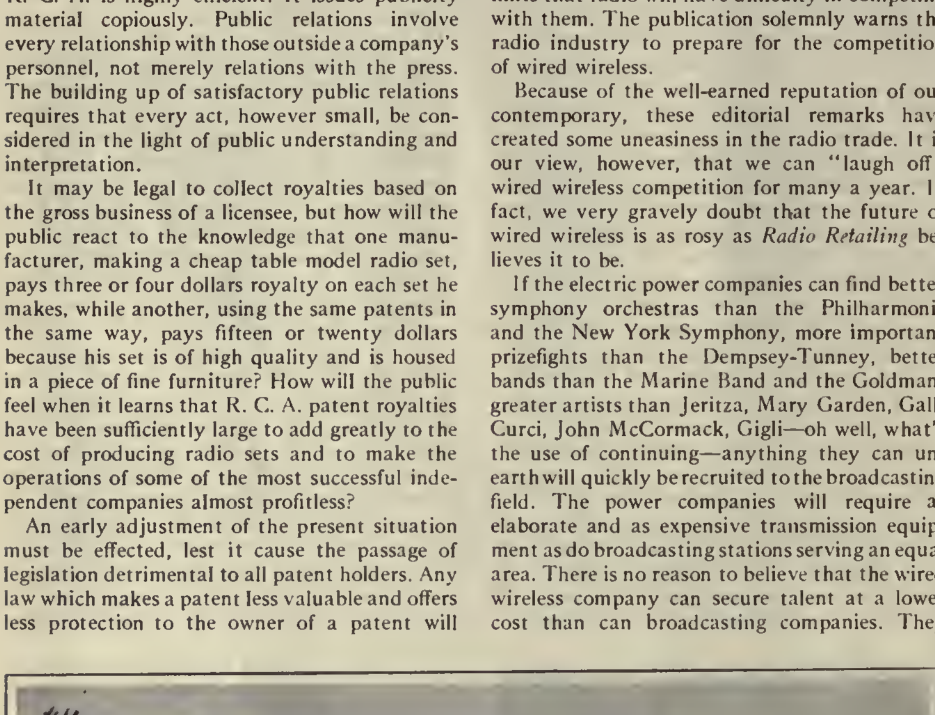
Because of the well-earned reputation of our contemporary, these editorial remarks have created some uneasiness in the radio trade. It is our view, however, that we can "laugh off" wired wireless competition for many a year. In fact, we very gravely doubt that the future of wired wireless is as rosy as *Radio Retailing* believes it to be.

If the electric power companies can find better symphony orchestras than the Philharmonic and the New York Symphony, more important prizefights than the Dempsey-Tunney, better bands than the Marine Band and the Goldman, greater artists than Jeritza, Mary Garden, Galli Curci, John McCormack, Gigli—oh well, what's the use of continuing—anything they can unearth will quickly be recruited to the broadcasting field. The power companies will require as elaborate and as expensive transmission equipment as do broadcasting stations serving an equal area. There is no reason to believe that the wired wireless company can secure talent at a lower cost than can broadcasting companies. They cannot claim better transmission quality because power lines also have their share of atmospheric noises and, in addition, current surges and disturbances which are fully as great, if not greater, than those with which radio contends. They cannot claim more faithful reproduction because radio now encompasses practically all the frequencies heard by the human ear. Wired wireless has no advantage over radio in cost of program and technical operations or in reproduced result.

The most important claim, made by the supporters of wired wireless, is that it will not put forth publicity programs. Wire broadcasting will derive its revenue, not from transmission, but from reception. The consumer will pay directly at a rate probably ranging between three and ten or twelve dollars a month, depending upon whether he is content to use headphones or wishes high-grade loud speaker reception. We hazard the prediction that the electric power companies will, sooner or later (and probably sooner), yield to the temptation of making occasional remarks about electrical appliances, good lighting and a few other things which will promote the sale of electrical apparatus and increase current consumption. The monthly wire broadcasting toll will be a much more serious obstacle to spreading wired wireless than is the publicity accompanying commercial radio programs to the growth of the broadcasting audience.

The American public is not accustomed to paying for something which it can secure without direct payment. The monthly payment feature of wired wireless will confine its market very largely to public places, such as restaurants, hotel lobbies, and railroad station waiting rooms. That element of the consuming public which considers programs coming over an electrical circuit so superior to radio reception that it is waiting for the coming of wired wireless is not, and never has been, a prospect for radio sets.

We believe our contemporary has considerably exaggerated the possibilities of wired wireless. The radio industry has little or nothing to fear from its competition. Wired wireless will serve a field peculiar to itself and has a valuable mission to perform but, in so doing, it will not be a serious or dangerous competitor to the radio industry.


Wir gestatten uns
die Herren Mitglieder des Landtages,
den Herrn Preuss. Minister des Innern
sowie die Herren Vertreter der Presse
auf bildtelegraphischem Wege in [illegible] herzlichst
zu begrüssen, mit dem Wunsche, dass durch die
Bildtelegraphie die Schlagkraft der Polizei weiter
erhöht und die wichtige Förderung des Funksteck-
briefes der Polizei zum Nutzen, dem Verbrecher
zum Schrecken bald praktisch verwirklicht
werden möge.

Der Vorstand
der
C. Lorenz Akt. Ges.

A SAMPLE OF FACSIMILE TRANSMISSION BY THE KORN SYSTEM

Congress Dabbles with the Radio Situation

CONGRESS has been intensely busy tinkering with the radio situation during the last few months. The House Committee on Marine and Fisheries, the Senate Committee on Interstate Commerce, and the Senate Patent Committee have been the scene of endless hearings, inquiring into every phase of broadcasting and radio manufacturing. The result, at the time of writing, has been to paralyze the Federal Radio Commission into almost complete inactivity and to confuse the entire situation with a riot of rabid opinions.

It is likely that some form of legislation will be passed by the time this editorial appears, presumably extending the life of the Radio Commission for another year. The opposition to this course is based largely on a desire to embarrass Secretary Hoover with the radio situation by the automatic operation of the unamended Radio Act of 1927. If the situation does revert to his jurisdiction, he must make some progress with it and, in so doing, will incur the enmity of politicians in the areas affected. Thus Congress, unable to help the radio situation by intelligent legislation, proceeds to use it to its own political advantage.

Nothing of particular novelty has been revealed in any hearings and only one statement of importance has been made. A bill has been pro-

posed to clarify the equitable distribution of broadcasting service clause of the Radio Act of 1927. The total wattage of broadcasting stations in the southern district is less than that of the largest single station in the northeastern district. The Federal Radio Commission is being blamed for this situation and is charged with discrimination against the south. To bring about a modification, the bill proposes that the total wattage of the five districts shall be equalized.

Commissioner Caldwell responded to this destructive suggestion by pointing out that the principal program sources of the entire country would, by the operation of such a provision, be required to suffer substantial power cuts, depriving immense rural populations of their favorite program services. There are neither stations nor frequency space sufficient to bring up the total wattage in the less progressive areas (speaking only from the broadcast transmission standpoint), and, consequently, the only possible way in which to observe the proposed law would be to reduce the power of every station in the New York district by eighty per cent., or eliminate a large number of medium and high-power stations. Many of the politicians were highly irritated by Commissioner Caldwell's succinct exposition of the situation but, so forceful was his logic that the only answer, so far made, has consisted of pointed and—it seems to us—unjustified insinuations about the Commissioner's susceptibility to the influence of the great broadcasters.

Commissioner Caldwell is to be commended for stating the facts so plainly and having the courage, at this time, to stick to the truth even though it be favorable to the viewpoint of the N. B. C. Political wisdom dictates a different attitude but he is swayed only by a desire to serve the listener.

The only other activity of the Commission has been the issuance of a formidable list of frequency and power changes by Commissioner LaFount, affecting stations on the Pacific Coast. These changes promise to clear up many existing heterodynes. It seems quite apparent, at this writing, that congressional bungling will prolong the present unsatisfactory radio situation for another year.

BAIRD TELEVISION APPARATUS ON SALE

PRESS dispatches from London announce that Selfridge's is selling Baird television outfits at a price of thirty-two dollars per set. Investigation reveals, however, that this equipment consists only of the parts for building a shadowgraph transmitting outfit. The amateur transmitting enthusiast can send, at his home, a moving hand or a shadow made by a cardboard figure held before the outfit. The cost of the receiver parts, to be marketed later, will be approximately the same. The shadowgraph offers a field for entertaining home experiments and it should promote interest in the problems of television.

As to the commercialization of television in the United States, a statement made by David Sarnoff of the Radio Corporation of America, before the New York Electrical League, is significant. He is quoted in the press as saying: "We will hear much more about these developments within the next year. My guess is that, within five years, they (television receivers) will be as much a part of our life as sound broadcasting is now."

An unnamed representative of the R. C. A. is quoted in the New York *Times*, when questioned as to how soon the Alexanderson still picture transmission apparatus will be placed on the market, as follows: "Oh, it will be a long time. Look at the apparatus. It is too cumbersome. It is only in experimental form."

GERMAN POLICE USE THE KORN PICTURE SYSTEM

In recent months, the Korn picture transmitting system has been adopted for regular use by the German police. The illustration shows a sample of the received picture. Average transmitting time for a picture is said to be 2½ minutes

Considering the great number of years that photo transmission has been the subject of experiment both here and abroad and the success obtained by such pioneers as Korn, Jenkins and Baird, and the recent successes of the Bell Laboratories and Alexanderson, it is surprising that picture broadcasting is so slow in becoming a supplement to tone broadcasting.

PICTURE BROADCASTING MUST CONTAIN NO "ADS"

MR. DAVID CASEM, Radio Editor of the New York *Telegram*, pointed out editorially recently that numerous commercial broadcasters are already considering ways and means in which they can use picture broadcasting. He points out that, if picture transmission is used to distribute miniature billboards in the home, its growth will be stifled at the outset. The public is not going to buy picture receiving apparatus in order to have itself exploited by advertisers.

Mr. Casem's point is well taken. Picture broadcasting must adhere to the highest standards of education and entertainment, if it is to be popularized. We have interviewed many broadcasting station managements on this subject, and have found that this fact is generally appreciated. Program managers have apparently learned that the first and most important factor to be considered in any radio presentation is that it shall please the radio audience. To this rule, picture broadcasting is no exception.

ANNUAL REPORT OF THE R. C. A.

THE annual report of the Directors of the Radio Corporation of America to stockholders, for 1927, indicates a substantial improvement in the corporation's financial position. The net income transferred to surplus amounts to \$8,478,320, as compared with \$4,661,397 for the previous year. About seven per cent. of its gross business is the result of its transoceanic services, the need for which inspired certain naval officials to encourage the company's original formation. Its combined transoceanic and marine business is but nine per cent. of its total business. It collected, during 1927, \$3,310,722 for royalties, of which about one and a third million cover past damages. An interesting item among its assets is nearly ten and a half million dollars in accounts receivable. It is not generally considered that this is largely inventory and it may be mostly uncollected royalties. Although more than three million dollars were collected as patent royalties, a good part of the surplus has been devoted to reducing the value of the patents credited in the balance sheet. They are now down to a little over five and a half million.

THOSE interested in studying sales and distribution figures will find the report compiled by the Electrical Equipment Division of the Bureau of Foreign and Domestic Commerce, aided by N. E. M. A., on stocks of radio equipment in the hands of radio dealers, very illuminating. This is the second of a series of quarterly reports to be issued. A little over 30,000 dealers contributed to the information. On October 1, the dealers had 65,921 battery sets in stock and,

THE KORN SYSTEM OF RADIO PICTURE TRANSMISSION

Doctor Korn (extreme right) demonstrating his latest transmitter to German police officials. Synchronism is achieved by synchronous motors and the received picture is made on light-sensitized paper revolving on a drum in a light-proof chamber. It is said that the armies of Italy and Japan use the Korn "telautograph" which enables aeroplane observers to draw simple maps and then radio them direct to their bases

on January 1, the number had fallen to 62,778. The total stock on hand averages but two per dealer, a number insufficient to cause uneasiness.

Here and There

THE Association of National Advertisers has appointed a committee to make a survey of broadcasting as an advertising medium. They will endeavor to ascertain the average audience listening to a radio program. Their task is equivalent to determining the number of crickets chirping at any given instant, in a swamp, on a foggy summer evening.

LIEUTENANT Commander Craven has been assigned to the Federal Radio Commission by the Navy Department to grapple with the short-wave problem.

ALTHOUGH it is definitely known that both the N. B. C. and the Columbia chains will have microphones at the political conventions, just how these events will be handled is not yet made clear. Both chains have commitments to commercial broadcasters and any alterations to their schedules are made at the price of commercial income. Mr. Aylesworth of the N. B. C. has pointed out these difficulties and issued a general hint through the press that the entire convention proceedings might be sponsored by one commercial broadcaster. It appears that there was no great rush of volunteers as a result.

STATION WOAI, San Antonio, Texas, recently joined the N. B. C. network. It had been one of the few independent stations assigned a cleared channel by the Federal Radio Commission. The Commission has no control over the programs radiated by a station and is not in a position to require that an independent, assigned to a cleared channel, shall not use chain programs after receiving such an assignment.

ASST. Secretary of Commerce for Aeronautics William C. McCracken, Jr., announced that approval had been obtained for the erection of a radio control station at Key West to be operated by the Airways Division of the Lighthouse Service. It will provide and exchange weather information between terminal airports, radio communication to aircraft in flight, and a radio direction service.

THE transatlantic telephone service has been subjected to a forty per cent. cut in rates, reducing the basic rate from New York to London to $45 for three minutes and $15 for each succeeding minute. The hours of service have been extended to from 7:30 A. M. to 8 P. M. Eastern Standard Time, corresponding to 12:30 P. M. to 1 A. M. in Great Britain. The service to Berlin, Hamburg, and Frankfort was inaugurated on February 10, and to Sweden on the 20th.

THE Department of Agriculture is extending its broadcasting service through NAA, Arlington, by issuing weather reports on several frequencies, both in telegraph and voice. The new schedule will benefit aviation and agriculture in particular.

OFFICIAL reports of American exports of radio apparatus in November indicate their aggregate value to be about one and a quarter million dollars, with Canada, Argentine, Australia, and Uruguay the largest purchasers. ❦ ❦ ❦ A CHINESE broadcasting organization has been formed which will rent time from a radio telephone plant at Shanghai. A subscription of ten dollars a year is to be charged each member to meet the cost of providing programs and employing announcers. ❦ ❦ ❦ THE MUNICIPAL authorities of Buenos Aires are planning to extend the service of their station, LOS, in the Colon Theatre, which has so far been used exclusively for broadcasting operas and concerts from the stage of the theatre. ❦ ❦ ❦ THE NUMBER of licenses in the Australian broadcasting system has now reached 300,000. One high-power station has been erected in each capital city, and in Melbourne and Sidney there are two. Telephone lines for interchange of programs are frequently used. ❦ ❦ ❦ A CONTROVERSY rages as to radio concessions extended by various Chinese administrations. Japan has an agreement, negotiated by the Chinese Ministry of the Navy, which gives it a monopoly for thirty years. In 1921, the Federal Telegraph Company made a contract with the Chinese Ministry of Communications for five stations to be operated by the American company for twenty years. The British also obtained contracts on behalf of the Marconi Wireless Telegraph Company. Apparently an exclusive license in China is non-exclusive. ❦ ❦ ❦ IN EUROPE, the International Radiophone Union regulates the frequencies and time assignments of broadcasting stations. The Hungarian Government has been barred from admission to this organization at the plea of Czecho-Slovakian delegates. The Hungarians have been accused of using their stations to spread propaganda, attacking the Treaty of Trianon, thereby, endangering the integrity of Czecho-Slovakia. ❦ ❦ ❦ ALL EXISTING telegraph records were broken during the Christmas season in England when the inter-empire beam radio telegraph system transmitted no less than 31,694 Christmas greetings from Great Britain to the dominions at a speed of 400 words per minute, without a single repetition being required. ❦ ❦ ❦ GERMAN POLICE systems have adopted the Korn system of picture transmission which is built along lines which have become conventional. Korn is a pioneer in the field, having, as early as 1907, transmitted newspaper photographs between Paris and London. Synchronous motors and neon lights are used.

THE PATENT SITUATION

IN A decision released February 18, the District Court for Delaware held that Clause IX of the Radio Corporation of America license agreement with radio set manufacturers constituted an unfair method of competition in violation of the Clayton Act. Clause IX of the license agreement required that each set made under license be equipped with a complete complement of R. C. A. tubes, sufficient to make them initially operative. A suit for $10,000,000 damages was subsequently brought by a group of independent tube manufacturers who avowed that the operation of this clause virtually paralyzed their business. Section III of the Clayton Act specifically provides that its provisions shall apply whether the article, in behalf of which unfair methods are employed, is patented or not.

In a suit brought by the Westinghouse Company, under the Armstrong patent, against the Tri-City Radio Company, the effect of continued acquiescence and acceptance of royalties on certain regenerative sets sold prevented the collection of damages. The Tri-City was a licensee under the Armstrong patent prior to its acquisition by the Westinghouse Company. It appointed a sub-manufacturer to make the goods for it, although the original license did not permit such sub-manufacture

—E. H. F.

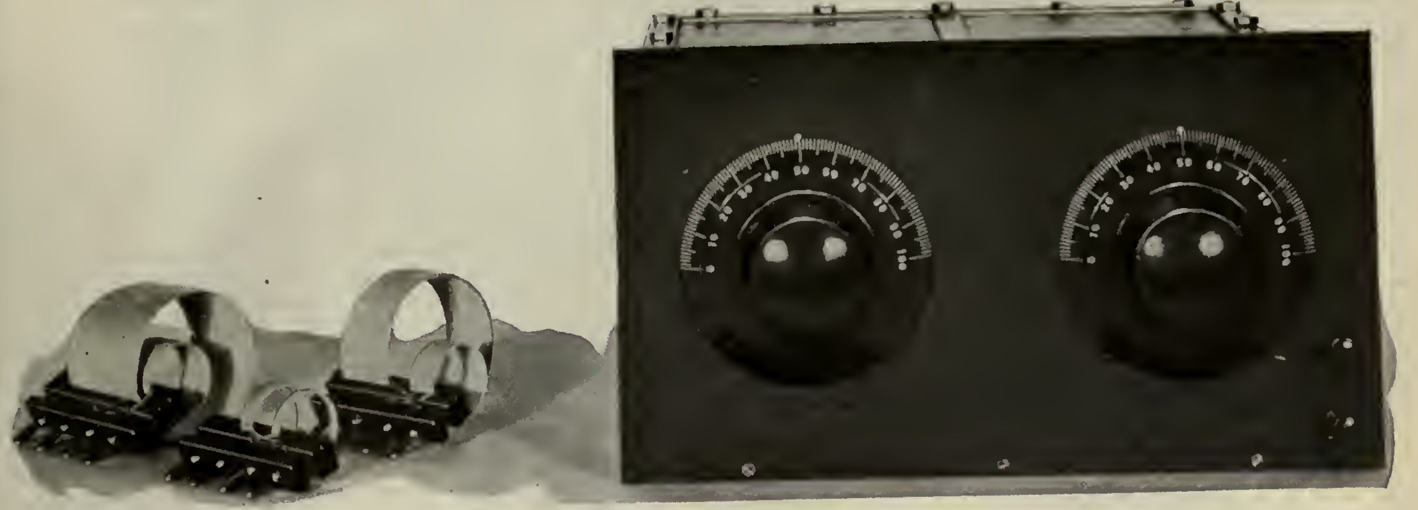
Estimated Number of Radio Receivers in Use

United States, January 1, 1928

THROUGH the courtesy of the radio division, National Electrical Manufacturers' Association, the figures showing the number of radio sets now in use are presented. New York, California, and Illinois, are the leaders in order, according to this survey. Note the number of estimated sets in the southern states, figures which are interesting, in view of the efforts of some Congressmen, especially from southern states, to have an "equitable station-power distribution" clause made a part of the present radio act.

STATE	TOTAL SETS	STATE	TOTAL SETS
Alabama	45,000	Nebraska	118,000
Arizona	25,000	Nevada	15,000
Arkansas	42,000	New Hampshire	25,000
California	704,000	New Jersey	209,000
Colorado	89,000	New Mexico	18,000
Connecticut	125,000	New York	876,000
Delaware	15,000	North Carolina	48,000
District of Columbia	44,000	North Dakota	35,000
Florida	73,000	Ohio	464,000
Georgia	64,000	Oklahoma	104,000
Idaho	26,000	Oregon	121,000
Illinois	539,000	Pennsylvania	501,000
Indiana	184,000	Rhode Island	53,000
Iowa	176,000	South Carolina	22,000
Kansas	104,000	South Dakota	41,000
Kentucky	46,000	Tennessee	52,000
Louisiana	74,000	Texas	188,000
Maine	39,000	Utah	33,000
Maryland	56,000	Vermont	19,000
Massachusetts	328,000	Virginia	56,000
Michigan	336,000	Washington	217,000
Minnesota	129,000	West Virginia	50,000
Mississippi	28,000	Wisconsin	169,000
Missouri	227,000	Wyoming	20,000
Montana	29,000	TOTAL	7,000,000

A Universal Short-Wave Receiver



A SHORT-WAVE RECEIVER FOR 11.2 TO 219 METERS

Its construction is fully described in the article below, data for making the coils also being given. The three coils shown by the side of the receiver are for the 175, 80, and 20 meter ranges. A table on page 14 gives the number of turns for various frequency bands

By Lloyd T. Goldsmith

Col. E. H. Green Radio Research

THIS article describes the construction of a single-tube receiver and coils to go with it to cover the frequency band between 1.37 and 26.7 megacycles (11.2 to 219 meters approximately). The receiver may be used with any audio amplifier system.

It is completely shielded in a copper box $10\frac{3}{4}''$ wide, $9\frac{3}{4}''$ deep, and 6″ high. The copper sheet from which the box is made is $\frac{1}{32}''$ thick. All joints are soldered and the top opening of the box is reënforced with $\frac{1}{2}''$ by $\frac{1}{2}''$ by $\frac{1}{16}''$ angle brass which is soldered to the copper. Holes are drilled in the angle brass for $\frac{3}{8}''$ 8-32 machine screws with which to fasten on the cover. The screws are soldered into the angle brass. The cover is of sheet copper reënforced at the edges and center with a strip of brass $\frac{1}{2}''$ wide by $\frac{1}{16}''$ thick. Holes are drilled in the strip around the edge of the cover to allow the cover to fit down on the angle brass where it is tightly held by hexagonal nuts. Although it takes a few moments to remove and replace the cover when changing coils, this method of shielding has been found to be very complete and mechanically strong.

The copper box is screwed to a 10″ by $11\frac{1}{2}''$ by $\frac{5}{16}''$ wood baseboard to which is also fastened by three wood screws the 7″ by 12″ bakelite panel. The only objects on the panel are the tuning and regeneration controls and the output binding posts. Note that the copper box is not centered behind the baseboard but is set in $\frac{1}{4}''$ from the left-hand edge of the panel in order to allow room for the output binding posts at the right.

At the rear of the set there is a bakelite strip on which are mounted four binding posts for connections to the antenna, A battery, and to the detector positive terminal of the B battery. The three battery wires go into the copper box through one hole and the antenna lead through another. Most of the parts are mounted on an inside baseboard $10\frac{1}{4}''$, by $8\frac{1}{2}''$, by $\frac{5}{16}''$ thick.

As will be seen by reference to Fig. 1, the antenna is coupled to the antenna coil through a General Radio midget variable condenser of 15-mmfd. capacity, C_1. A General Radio coil mounting holds the plug-in coils and is spaced a generous distance from the sides of the box. The tuning condenser, C_3, is a Cardwell of 50-mmfd. capacity of the straight frequency-line type. The regeneration condenser, C_2, is a National of 250-mmfd. capacity. The latter two condensers are mounted directly on the copper box and bakelite panel. Each is provided with a 4″ National Velvet vernier dial.

The grid condenser, C_4, is a 100-mmfd. Sangamo across which is a Tobe 8-megohm grid leak, R_1. The detector tube is a UX-201-A and fits in a General Radio UX type socket mounted on a General Radio rubber cushion to absorb shocks and reduce noises. The leads to the socket are of flexible rubber-covered wire. The radio-frequency plate choke, L_3, is a Samson No. 85 of 85 mh. inductance The audio-frequency choke, L_4, in the positive B-battery lead is a Samson No. 3 of 3 henrys inductance. The audio-

A "Super" for Code Work

THE short-wave receiver described in this article has been designed for use with any ordinary audio amplifier, and when so used, will be found extremely sensitive, especially for code reception. The main purpose for its design, however, is its adaptation to the super-heterodyne unit described on the pages following those devoted to the present article. The super-heterodyne combination will not be satisfactory for short-wave phone reception due to the peaked characteristics of the intermediate-frequency amplifier. It will, on the other hand, be wonderfully sensitive for code reception.

—THE EDITOR.

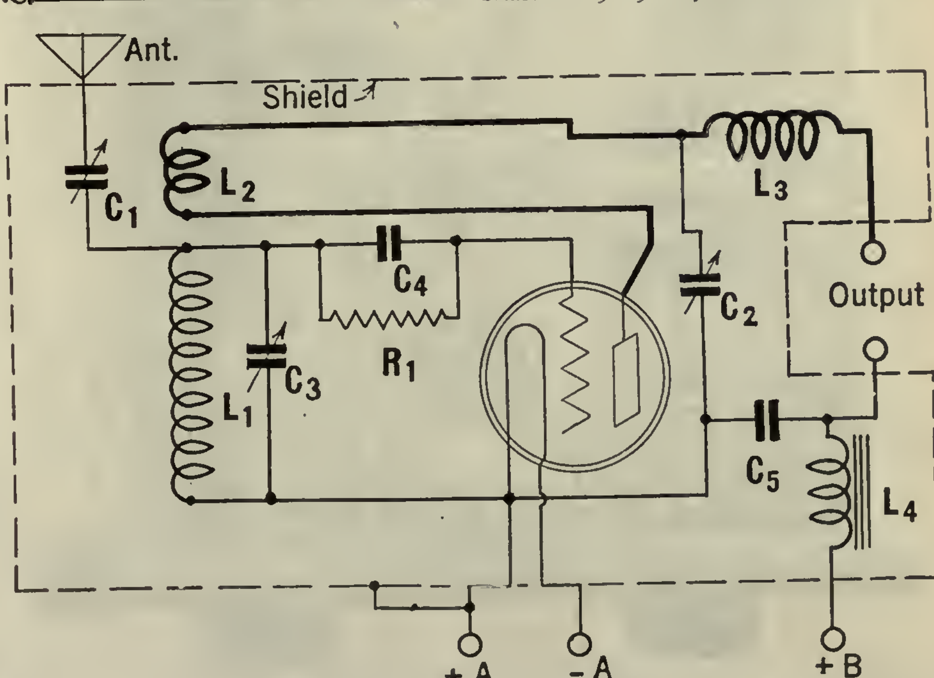


FIG. 1

Circuit diagram of the short-wave receiver described in this article

frequency current is bypassed to filament through a 1-mfd. Tohe condenser, C_5, which in the photograph can be seen mounted on the base-board beneath the regeneration condenser. The copper box is grounded to the positive A binding post.

No rheostat, filament switch, or voltmeter is provided on the receiver because it is designed primarily to be used with the screen-grid tube super-heterodyne described in the article following this one in this same issue, and common A and B batteries are used, the A battery connections for the receiver being taken off the filament terminals of the second detector socket of the superheterodyne. In this way the filament switch on the super-heterodyne controls the filaments of all the tubes, and the voltmeter reads their filament voltage, which is adjusted by the master rheostat.

The plug-in coils are mounted between ½" bakelite strips provided with General Radio type 274-P plugs. The socket, or base, into which the coils are inserted, is a General Radio 274-B base, which retails complete for $1.00. The plugs on the coils must be so spaced that they will plug into this standard base. The tickler is mounted next to the antenna coil when it is of the same diameter as the latter, but in the larger coils, to save space, it is mounted within the secondary coil. In any case, the tickler should be at the filament end of the secondary coil.

The coils are wound on a bakelite tuhe which has been cut in half diametrically and held together by hrass end rings. Fig. 2 shows the construction of the coil form. The desired number of turns is wound on the form and given two light coats of collodion. When the coil is dry the screws are removed from the end rings, the latter are slipped out, and the bakelite form is pushed together so that the coil can be slipped off. The inside of the coil is then given a coat of collodion to add to its mechanical strength.

The accompanying table gives data on the number of turns, size of wire, diameter of the coil, and the frequency band covered with the tuning condenser used. In the front view of the receiver are shown the 175-meter coil, the 80-meter coil, and the 20-meter coil, while the interior view of the set shows the 40-meter coil in place.

Elaborate constructional details have not been given in this article for it is felt that those interested will be sufficiently versed in the art of amateur set construction to build the receiver from those data presented. The layout of apparatus can be distinctly followed by reference to the photographs, and the circuit diagram is so simple as not to require an elaborate explanation.

The receiver as described is complete and ready for operation with any audio amplifier. It was primarily designed, however, for code reception, and particularly to be used in conjunction with the super-heterodyne unit described in the article beginning on the next page.

The following parts are required for the single-tuhe receiver described:

Secondary Coil			Tickler Coil			Bands	
No. of Turns	*Diameter (Inches)*	*Size of Wire (D.C.C.)*	*No. of Turns*	*Diameter (Inches)*	*Size of Wire (D.C.C.)*	*Frequency (Megacycles)*	*Wavelength (Meters-Approx.)*
4	1¼	18	3	1¼	22	16.7 –26.7	18 –11.2
7	1¼	18	4	1¼	22	11.5 –18	26.1–16.7
11	1¼	18	6	1¼	22	8.3 –13.3	36.2–22.6
9	2½	18	10	1¼	22	6. – 9.4	50 –31.9
14	2½	18	13	1¼	22	4.2 – 6.52	71.4–46
23	2½	18	16	1¼	22	2.87– 4.6	104.5–65.2
37	2½	18	19	1¼	22	2.1 – 3.33	143 –90
54	2½	22	22	1¼	22	1.37– 2.17	219 –138

A TABLE OF COIL SIZES

Comp'ete details of the number of turns for the secondary coil, L_1, and the tickler coil, L_2, for various frequencies are incorporated in this table

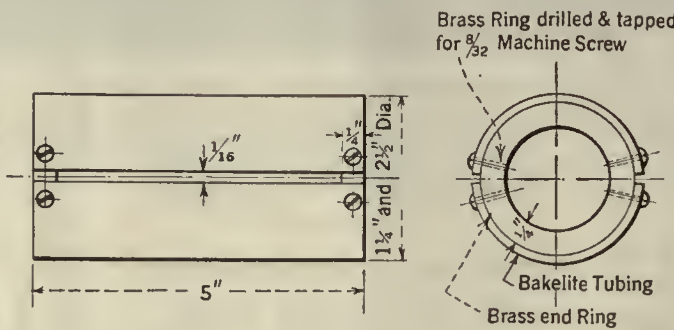
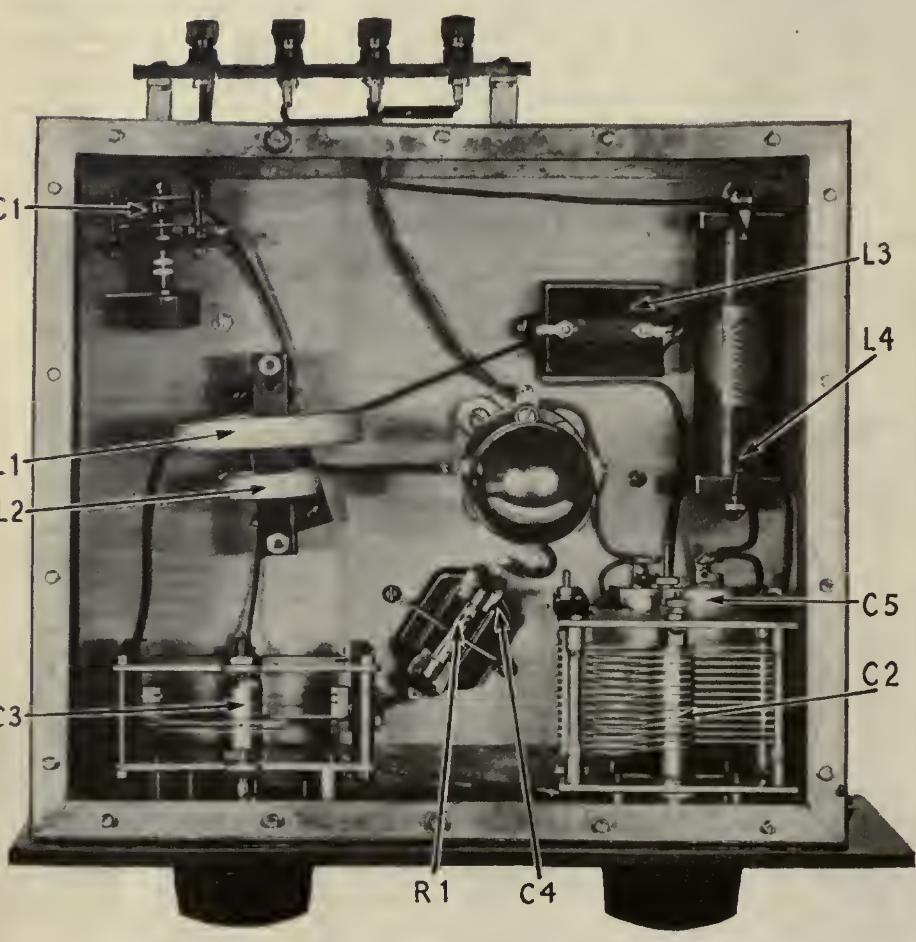


FIG. 2

Constructional deta ls for the coil form

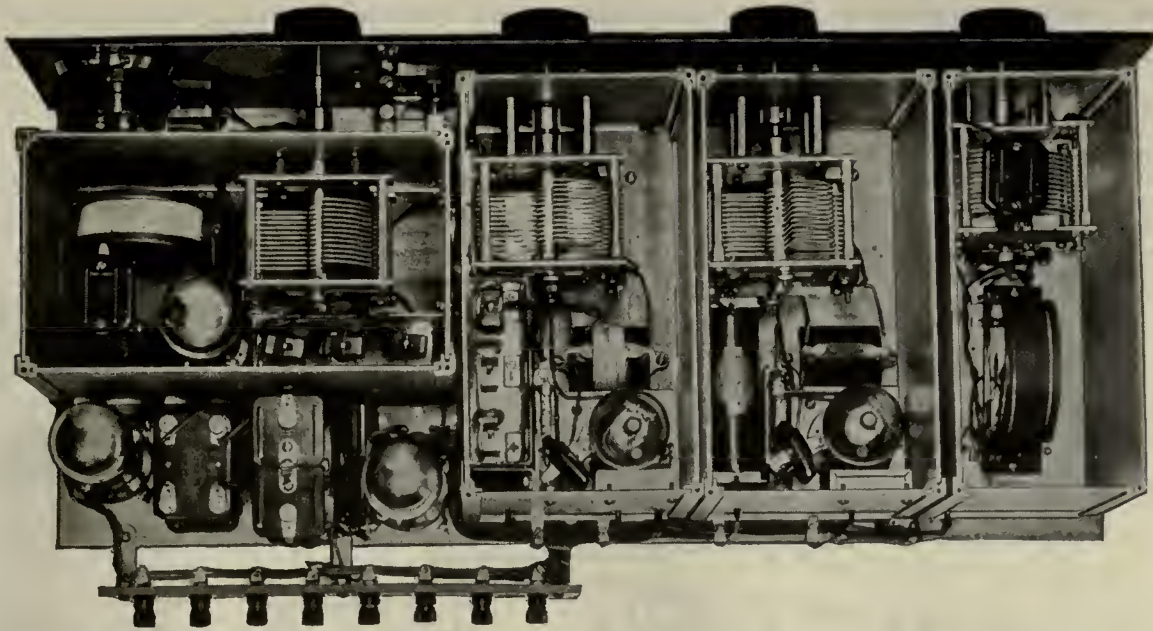


AN INTERIOR VIEW OF THE RECEIVER

The parts are numbered for cross reference to the list of parts in the column immediately to the right

List of Parts

C_1—General Radio 15-Mmfd. Midget Variable Condenser
C_3—Cardwell 50-Mmfd. Variable Condenser
C_2—National 250-Mmfd. Variable Condenser
C_4—Sangamo 100-Mmfd. Fixed Condenser
C_5—Tobe 1-Mfd. Fixed Condenser
R_1—Tobe 8-Megohm Grid Leak
L_1, L_2—Plug-in Coils (Specifications in Text)
L_3—Samson No. 85 Choke
L_4—Samson No. 3 Choke
General Radio UX Tuhe Socket
Six Eby Engraved Binding Posts
General Radio No. 274-B Coil Mount
General Radio Rubber Socket Cushion
Two 4" National Velvet Vernier Dials
7" x 12" x 3/16" Bakelite Panel
10" x 11½" x 5/16" Wood Baseboard
10¼" x 8½" x 5/16" Wood Baseboard
1/32" Copper Box with Cover 10¾" x 9¾" x 6"
Brass Angle, Brass Strip, Angles, etc.



TWO SCREEN-GRID TUBES ARE USED IN THE INTERMEDIATE AMPLIFIER OF THIS SUPER-HETERODYNE UNIT
The unit has been devised for use with an existing short-wave receiver (such as that described in the previous article), converting it into a remarkably efficient short-wave super-heterodyne, especially suited for code signals

A Super-Heterodyne for Short-Wave Code Signals

By Lloyd T. Goldsmith

THE standard receiver used for short-wave code reception usually consists of a detector (such as that described in the preceding two pages) and one stage of audio-frequency amplification, although sometimes a second audio stage is used in an effort to secure more volume. In the latter case, unless a selective amplifier is used, the noise level is amplified in about the same proportion as the received signal, which is undesirable, as the real aim is to amplify the signal and not the noise. This difficulty suggests that the signal be amplified at a radio frequency rather than at an audio frequency in an effort to amplify it more than the noise background. Radio-frequency amplification at very high radio frequencies has not been found very satisfactory but if the signal be changed to a radio frequency of the order of 20 to 100 kilocycles, amplification is not only satisfactory for the signal gain alone but from the point of view of increasing the signal-to-noise ratio. This is what is done in the super-heterodyne. In addition, if the radio-frequency amplifier stages are sharply tuned, the selectivity of the receiving apparatus as a whole is very materially increased.

With the increase in the number of transmitting stations operating on the shorter waves the need is becoming greater for a receiver giving all possible practical selectivity. In an attempt to realize these requirements the super-heterodyne described in this article was built.

Super-heterodyne receivers using 201-A type tubes with impedance-coupled and tuned transformer-coupled intermediate-frequency amplifiers built and tested at the Massachusetts Institute of Technology have been found very much worth while in the reception of long-distance short-wave telegraph signals. Upon obtaining the new screen-grid tubes, a super-heterodyne was constructed at the Institute using these tubes as the intermediate-frequency amplifiers. The construction of this receiver is described here.

The arrangement, as will be seen by referring to Fig. 1, consists of two stages of intermediate-frequency amplification using screen-grid tubes, a beat frequency oscillator, a detector, and one stage of audio amplification, using 201-A tubes. The unit as a whole is intended to follow any short-wave receiver, using the latter's detector tube as an autodyne frequency converter, and changing the signal frequency to 50 kilocycles. The super-heterodyne unit is particularly adaptable to the short-wave circuit described on the previous two pages.

The first intermediate-frequency stage has a tuned transformer input circuit. The transformer, T, has an air core and is a spool made of $\frac{3}{4}''$ diameter bakelite having a winding space $\frac{3}{4}''$ wide by $\frac{7}{8}''$ deep. The secondary winding consists of 1000 turns of No. 28 d.c.c. wire. Over this are placed a few layers of paper to prevent possible grounding of the two windings. Over the paper the primary is placed, consisting of 250 turns of the same wire. The secondary can be tuned to an intermediate frequency of 50 kilocycles by means of a 500-mmfd. variable condenser or to 30 kilocycles if an additional fixed capacity of 1000 mmfd. is shunted across the variable condenser.

With a given plate voltage the voltage amplification of the screen-grid tuhe is directly proportional to the effective impedance which can be built up in its plate circuit. (See "Characteristics of shielded-grid Pliotrons," by A. W. Hull and N. H. Williams, and "Measurements of High-Frequency Amplification with Shielded-Grid Pliotrons," by A. W. Hull. Both of these papers appeared in the *Physical Review*, April, 1926, Vol. 27.) This fact should he kept in mind when choosing values of inductance and capacitance to be used as a coupling impedance. In this case the coils, L, are No. 85 Samson choke coils which can be tuned from 20 to 50 kilocycles by a 500-mmfd. variable condenser. Honeycomb coils were tried as coupling impedances and slightly greater amplification was obtained, but because of the ease of mounting and compactness of the Samson choke coils, they were used in the final receiver. These chokes are helical wound and although their direct-current resistance is higher than that of a honeycomb coil having the same inductance, their effective resistance at radio frequencies is much less.

The variable condensers are provided with insulating shafts to keep the radio-frequency circuits as far away from the panel as possible and all except the first are mounted on the shields with insulating pillars. The interstage coupling condensers, C_1, are of 2000-mmfd. capacity and the grid leak, R_1, is of 100,000 ohms. The B-battery voltage is 135 volts and the screen-grid voltage is 67.5 volts.

The filament voltage is reduced to 5 volts by means of a 2-ohm master rheostat in the positive A-battery lead and the filament voltage of the screen-grid tube is further reduced to 3.3 volts by 15-ohm fixed resistances, R, placed in each of their negative filament leads. The grid returns are brought to the battery sides of these resistances giving a grid bias, equal to the drop in the resistance R, of approximately 1.7 volts negative.

For grid detection in the second detector the grid condenser is of 2000-mmfd. capacity and the leak can be from 4 to 8 megohms where the plate voltage is 45 volts. Provision is made for a C battery if plate detection is used.

A small amount of regeneration or resistance neutralization is introduced into the plate coupling impedance of the second intermediate-frequency stage to secure increased amplification in that stage. The effective shunt impedance of the parallel circuit, consisting of the plate coil and condenser, is limited by the resistance of the circuit. The introduction of regeneration reduces this effective resistance, giving a greater effective impedance in the plate circuit, with

correspondingly increased amplification. (See "Complete Suppression of a Single Frequency by Means of Resonant Circuits and Regeneration," by J. A. Stratton. *Journal Optical Society of America.* Vol. 13, No. 1, July 1926.) Regeneration is accomplished by means of a small tickler, L_2, in the detector plate circuit of 25 turns wound directly on the plate coil of the second intermediate-frequency stage. The tickler can be cut in or out as desired by means of a switch, K, mounted on the front panel. The receiver was not designed for broadcast reception and with air condensers to tune the intermediate-frequency stages, the tuning is too sharp for quality reception. If, however, fixed condensers of the proper capacity are used to tune the intermediate stages, it is probable that the response curve would include a band 10 kc. wide. The amplification would probably be reduced accordingly. With a 50-mmfd. tuning condenser across the secondary of the short-wave detector out of voltage is then necessary as when receiving unmodulated signals.

The oscillator is a "shunt feed" Hartley type the frequency of which is regulated by a variable condenser of 500-mmfd. capacity in shunt with a fixed condenser, C_2, of 1000-mmfd. capacity for 30-kilocycle operation, or 750-mmfd. capacity for 50-kilocycle operation. The oscillator coil, L_3, consists of 1500 turns of No. 28 wire wound on the same kind of spool as is used for the input transformer, T, the filament tap being made one third of the way from the grid end of the coil.

Some difficulties were encountered in adding a stage of audio-frequency amplification as the separation between a 50-kilocycle radio-frequency signal and an audio-frequency signal of approximately 2 kilocycles is relatively small. To keep the 50-kc. component out of the audio-frequency circuit a single-section filter having a cut-off at approximately 5 kc. is used in the detector plate circuit of the detector. The filter is stage coupling through the B-battery leads. All battery binding posts, as well as the output posts, are mounted on a bakelite terminal strip at the rear of the set.

The aluminum shields are 5" by 6" by 9" except the first which was cut down to 4" by 6" by 9". The first shield contains the input transformer, with its secondary fixed, and variable condensers. The second and third shields contain the first and second stages of intermediate-frequency respectively, along with their associated coils, condensers, etc. The 15-ohm fixed resistance in the filament circuit of the first screen-grid tube is within its aluminum shield while the fixed resistance in the filament circuit of the second screen-grid tube is mounted at the rear of the baseboard behind the shields.

The input lead to the first stage is brought out through the top of the first shield and connects directly to the control grid cap of the first screen-grid tube, which projects through a hole in the

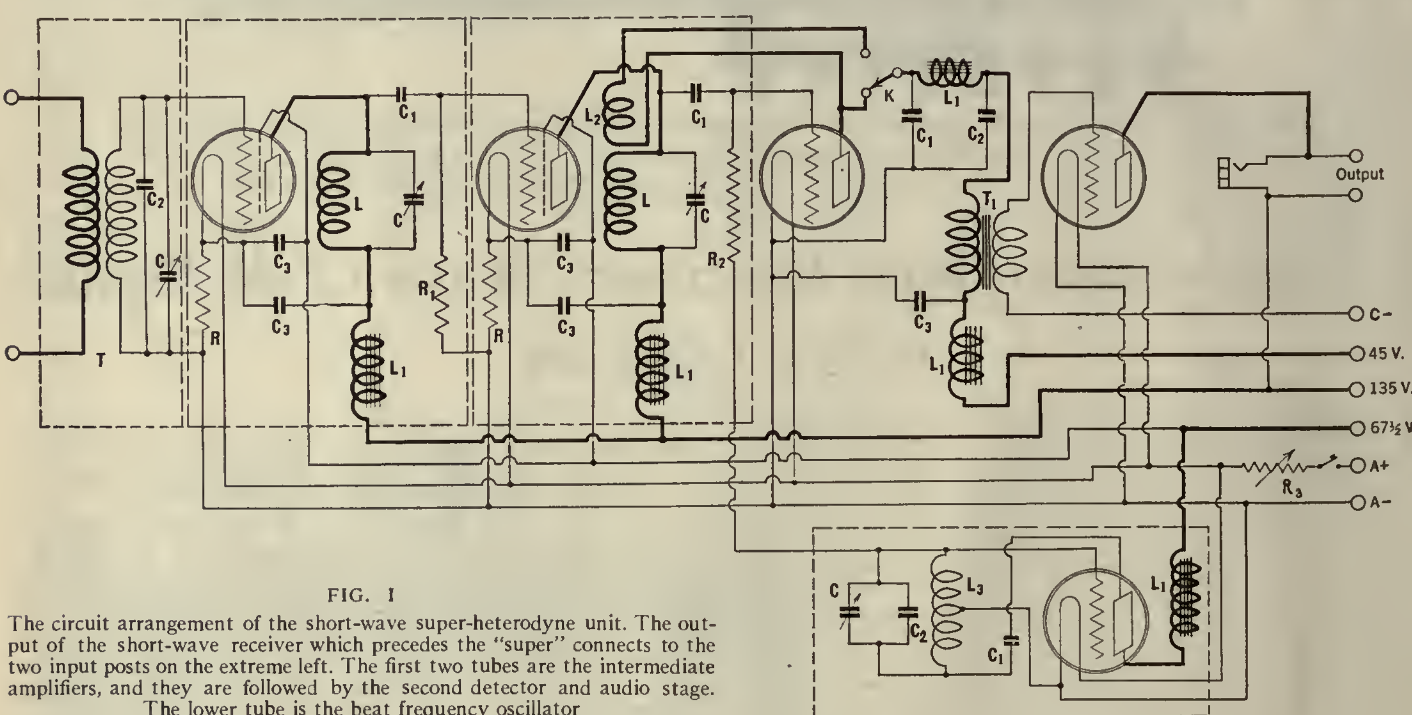


FIG. 1

The circuit arrangement of the short-wave super-heterodyne unit. The output of the short-wave receiver which precedes the "super" connects to the two input posts on the extreme left. The first two tubes are the intermediate amplifiers, and they are followed by the second detector and audio stage. The lower tube is the beat frequency oscillator

which this amplifier works, the outfit is as selective as one dares make it. An a.c. note appears and disappears in one half a division on the 100 division scale of the condenser when working in the 3- to 4-megacycle (75–100 meter) band.

In the ordinary short-wave receiver employing a simple oscillating tube as a detector of c.w. signals, the detector is made to oscillate at a frequency differing one or two kilocycles from the incoming signal and the resulting audible beat is heard in the telephone receivers. In tuning the detector when followed by the intermediate-frequency amplifier described here, the beat frequency is made an inaudible frequency of 50 kilocycles, instead of the usual one or two kilocycles. To reduce this to an audible frequency an oscillator whose frequency can be varied is made to beat with the 50-kilocycle intermediate frequency and give a difference frequency of one or two kilocycles as desired. The beating oscillator voltage is fed to the grid circuit of the second detector tube through the grid leak resistor.The audible beat frequency produced in the second detector is then amplified by the stage of audio amplification. For phone reception the oscillator tube is removed from its socket as no beating

a simple "pi" section consisting of a 3-henry choke in the detector plate lead preceded and followed by 2000-mmfd. and 1000-mmfd. fixed condensers respectively. The choke is a Samson No. 3 which has a small open iron core.

There is nothing unusual about the stage of audio amplification. The transformer is a Samson with a 6 to 1 ratio and there is provided a pair of output binding posts as well as the usual output jack. The B-battery voltage is 135 volts and the grid battery is 4.5 volts.

The baseboard is $23\frac{1}{2}$" by 10" by $\frac{1}{4}$". The front panel is of bakelite and is 24" by 7" by $\frac{3}{16}$". The first three dials tune the intermediate-frequency stages while the fourth controls the frequency of the beating oscillator. All the dials are 4" National Velvet Vernier dials. At the right there is provided a Weston double-range voltmeter to read plate and filament voltages while below it are the 2-ohm master rheostat, filament switch, and output jack. The regeneration switch is between the third and fourth dials and is a Yaxley jack switch of the single-pole double-throw type. The two input binding posts are at the extreme left of the panel. Plate-voltage leads are provided with Samson 3-henry chokes and 1-mfd. bypass condensers to prevent inter-

top of the shield. The output lead of the first amplifier stage is brought out through a hole in the top of the second shield and connects with the grid cap of the second shield grid tube, which projects through a hole in the third shield. To prevent pick-up by these leads they are wrapped in copper foil which in turn is grounded. This aids in the prevention of oscillation in the stages and helps materially in securing stable operation. The tube sockets are raised on blocks of wood in order that the control grid may project as far as possible through the hole in the top of the shield. The grid terminal is insulated where it is likely to come into contact with the edge of the hole and the grid lead is wound into a spiral spring which makes a tight connection to the grid terminal.

The last shield, placed at right angles to the first three, contains the audio beating oscillator. All the shields are connected together and brought to a binding post at the rear of the set marked "Ground." In this way effects of grounding the shields individually or collectively, the negative A alone, or shields and battery together, may be noted. Behind the oscillator shield there is the detector, filter, and the stage of audio amplification.

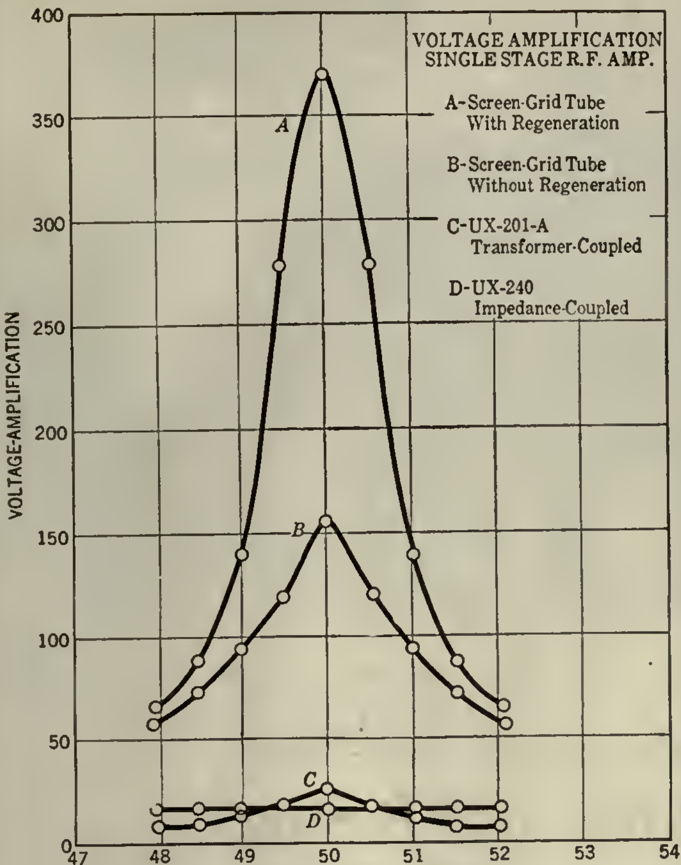


FIG. 2

Showing the voltage amplification for a single r.f. stage with or without regeneration and for different tubes and forms of coupling

EXAMINING THE CURVES

An examination of the amplification curves of Fig. 2 shows that at 50 kilocycles the maximum amplification obtained in one stage with the plate impedance used is 155 without regeneration and 370 with regeneration. By amplification is meant the ratio of the voltage appearing across the plate impedance to the voltage impressed on the grid. The curves also indicate the sharpness of tuning of a single stage. The amplification obtained in both stages of intermediate frequency is rather difficult to measure accurately because it is so great but is in the order of 25,000 with regeneration. The amplification obtained in the stages of intermediate frequency of other super-heterodynes built at Massachusetts Institute of Technology using UX-201-A tubes has been (see Fig. 2) in the order of 25 for one tuned amplifier stage and 16 for one stage of impedance-coupled amplification with high-mu tubes. (These data were presented in an unpublished report of Green Radio Research, Massachusetts Institute of Technology).

A compromise had to be made between greater amplification secured by increased regeneration, and sharpness of tuning. In the present arrangement the amplifier is not well adapted to the reception of voice and music as the width of the band of frequencies passed in a single stage is not more than 1400 cycles.

Too much stress cannot be laid upon the need of proper shielding when using the screen-grid tube. The grid leads from the tubes *must* be shielded from all the plate circuit apparatus of the same tube. The covers of the shields would be much better flanged to eliminate cracks after the cover is put on. The holes for the wires should be as few as possible and no larger than necessary All radio-frequency circuits should be kept within the shields, by the use of chokes and large bypass condensers in the plate circuits particularly.

The amplification curves were obtained by the substitution method using a vacuum-tube volt-meter. A 50-kilocycle voltage from an oscillator is impressed by means of a calibrated resistance on the input of the single stage and a reading is taken on the vacuum-tube voltmeter connected in the plate circuit of the detector. Then the stage is cut out and a second voltage is impressed upon the input terminals of the detector of such a value as will give the same reading on the voltmeter. This input voltage will be larger than when the stage of amplification is used and if the current through the variable resistances is kept the same in both cases, the voltage impressed will be directly proportional to the corresponding values of resistance. The ratio of the value of resistance used without the stage of amplification to the value of resistance used with the stage of amplification gives the voltage amplification of the stage. All measurements are made with the oscillator tube removed from its socket and a resistance of 10,000 ohms is placed in series with the test leads from the calibrated resistance to represent the plate resistance of the first detector which is normally shunted across the primary of the input transformer.

As has been mentioned, the amplifier is for code reception with any autodyne receiver and it may either be connected in place of the primary of the audio-frequency transformer of the receiver, or more simply by connecting its input terminals in series with the positive detector B-battery lead of the receiver.

The operation of the complete receiver is no more complicated than the operation of the usual two-control short-wave outfit. The first three dials of the amplifier are set at about the same values and a station tuned-in on the receiver while the oscillator dial is varied to give the desired note. The first three dials are readjusted carefully for maximum volume. Now the entire amplifier can be left untouched, all the tuning being done with the tuning and regeneration controls of the short-wave receiver. The regeneration switch on the amplifier can be used as a rough volume and selectivity control.

If the receiver described by the author on pages 13 and 14 is to be operated with the screen-grid super-heterodyne unit, the following statements hold. Because of the fact that the variable condenser across the secondary of the input transformer of the super-heterodyne unit is mounted directly on the aluminum shield, the ground post of the shields of the super-heterodyne cannot be directly grounded to the positive A battery but can be done so through a 1-mfd. fixed condenser. This is necessary because the copper shield of the receiver is necessarily grounded to the positive side of the A battery while the first aluminum shield of the "super" has been connected to the negative side of the battery. When using the two sets together, then, the positive side of the A battery is grounded and the shields of the "super" are connected to the positive A binding post through the large condenser.

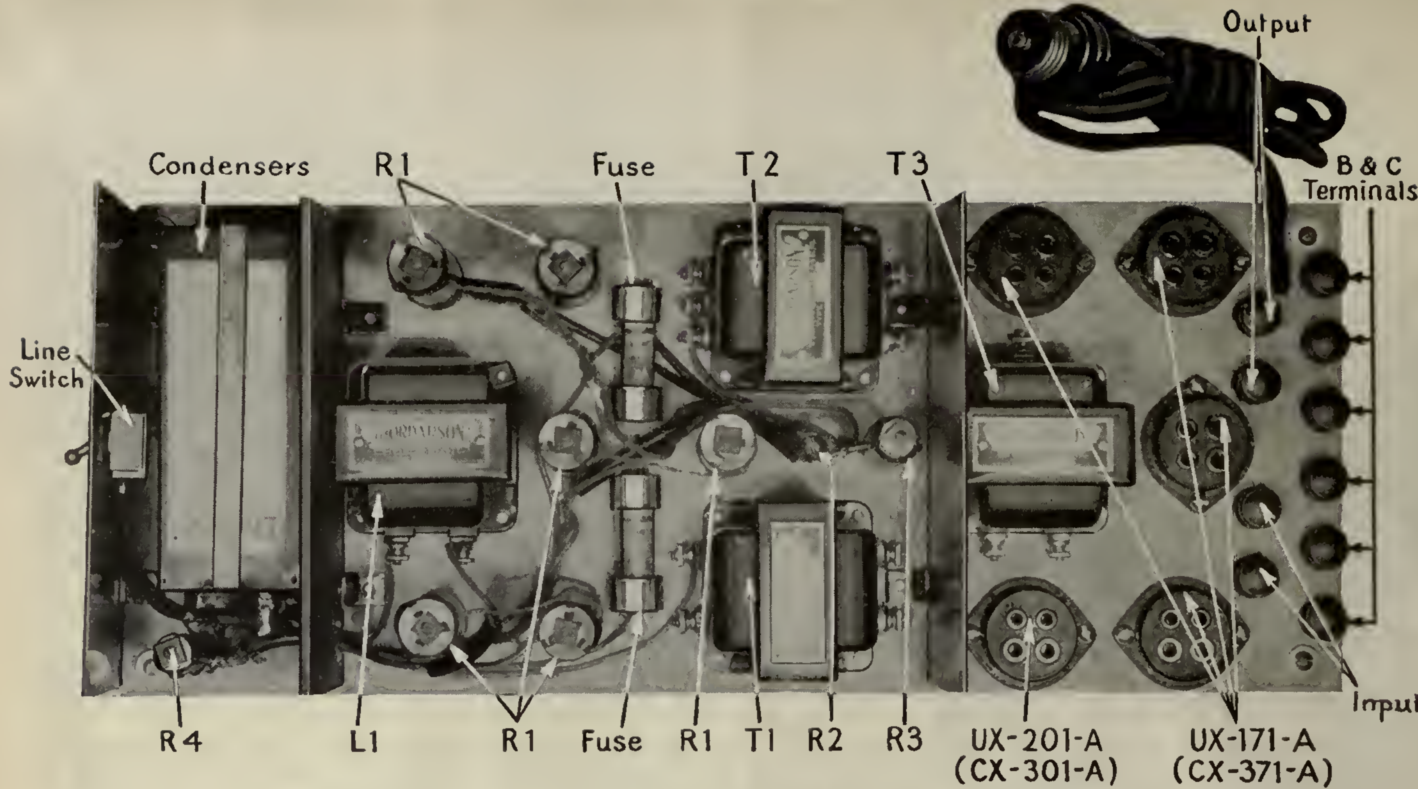
The following parts were used in the construction of the super-heterodyne unit:

LIST OF PARTS

T —Special Input Transformer (See Text)
T_1—Samson Audio Transformer, 6–1 Ratio
L —Two Samson No. 85 Choke Coils
L_1—Five Samson No. 3 Choke Coils
L_2—25-Turn Tickler Coil (See Text)
L_3—Special Oscillator Coil (See Text)
C —Four 500-mmfd. National Variable Condensers
C_1—Four 2000-mmfd. Sangamo Fixed Condensers
C_2—Three 1000-Mmfd. Sangamo Fixed Condensers
C_3—Five 1-mfd. Dubilier Fixed Condensers
R —Two 15-Ohm Carter Fixed Resistances
R_1—100,000-ohm Tobe Resistor with Mounting
R_2—4-Megohm Durham Grid Leak with Mounting
R_3—2-Ohm General Radio Rheostat
Five General Radio Sockets
Yaxley Filament Switch
K—Yaxley S.P.D.T. Jack Switch
Carter Midget Open-Circuit Jack
Ten Eby Engraved Binding Posts
Four 4″ National Velvet Vernier Dials
White Pine Baseboard $23\frac{1}{2}''$ by $10''$ by $\frac{1}{4}''$
Bakelite Panel $24''$ by $7''$ by $\frac{3}{16}''$
Aluminum Shields, Extension Shafts, Insulating Pillars, Angles, Wood Screws, Etc

A PANEL VIEW OF THE SHORT-WAVE "SUPER" UNIT

Despite the number of dials on the panel, the receiver is no more difficult to tune than the ordinary two-control short-wave receiver. After the dials on the super-heterodyne unit have once been set, all the tuning is done by means of the controls of the short-wave receiver which precedes the "super"



THE SIMPLICITY OF THE D.C. AMPLIFIER IS EVIDENT FROM THIS PHOTOGRAPH

A D.C. Power Amplifier and B Supply

By Victor L. Osgood

THE problem of getting really fine tone quality, power, and volume from an amplifier entirely electrically operated from a 115-volt direct-current supply is one that has frequently stumped the fan who does not live in a district where a.c. is available. Many still believe that it is not possible to do away with B batteries where the supply is d.c. in nature, and still get good quality and volume.

The problem for a time was a baffling one, but the introduction of power tubes, especially those of the 171-A type, has made possible the design of a power amplifier that has won the approval of all those who have heard it.

The solution lies in combining a stage of transformer-coupled amplification with a second stage of push-pull, using two tubes in parallel on each side of the push-pull system. Ninety volts are placed on the plate of the first tube (a UX-201-A or a CX-301-A) with a grid bias of 4.5 volts, and power tubes of the 171-A type are employed in the push-pull system with a plate potential of 105 to 110 volts and a grid bias of 22.5 volts. The input connection to the amplifier may be made directly to the plate of the detector tube in the receiver itself. Four UX-171-A (CX-371-A) tubes are used in the push-pull system, as shown in the schematic diagram, Fig. 1, and they can supply an output of 700 milliwatts to the loud speaker. This will be found ample to give excellent tone quality and volume. A push-pull amplifier sometimes has a tendency to oscillate and for this reason a 25,000-ohm resistance, R_3, is connected in the center tap lead of the input push-pull transformer to absorb any unbalance in the circuit which would otherwise tend to make the amplifier oscillate. The filaments of the 171-A type tubes in the power amplifier are lighted with power obtained from the 115-volt line after the voltage has been reduced by resistance R_1.

The circuit is arranged so that plate potential for the radio-frequency amplifying tubes and the detector is available; thus the necessity for B batteries is altogether eliminated.

Even though the supply is d.c. some filtering is necessary to eliminate the commutator ripple in the voltage. The filter circuit used here, however, is very simple, consisting of one choke coil, L_1, and a 4-mfd. filter condenser, C_1. Two 1-mfd. bypass condensers, C_2 and C_3, are also necessary across the two intermediate voltage taps. The d.c. voltage rating of these condensers need not be more than 160 volts. Either 67 or 90 volts are available for the plate circuits of the r.f. amplifiers, the choice of voltage depending upon the individual set and the owner's preference.

Biasing voltages are supplied by dry batteries. Were we to take the required 22.5 volts C bias from the power line, we would, of course, have to deduct just that much from the total voltage

About the Amplifier—

THE majority of self-contained electrically-operated receivers now on the market are designed to function by plugging into an alternating-current source. While there are some manufactured receivers now available for use where the supply is d.c., these are few and far between. Constructional articles on d.c. equipment have been equally scarce, mainly due to the fact that the districts where d.c. is supplied are considerably in a minority. The combined power amplifier and power-supply unit described in this article is especially for the much-neglected constructor whose house supply is d.c. It will handle as much undistorted output as will a single 171 type tube with 180 volts on the plate and 40.5 volts on the grid—sufficient for ordinary home purposes.

—THE EDITOR

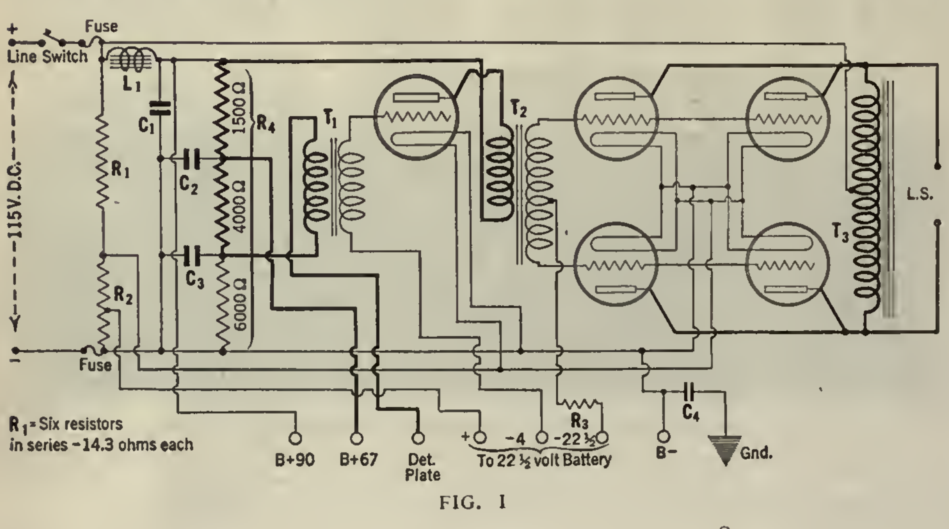
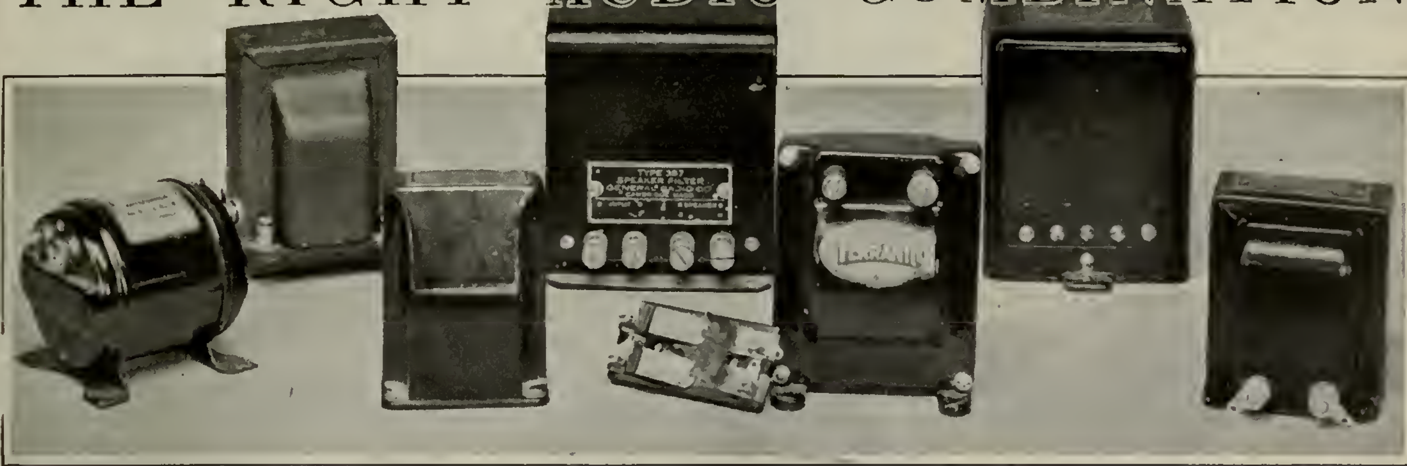


FIG. 1

THE RIGHT AUDIO COMBINATION



By L. W. Hatry

MANY set builders have searched for the ideal form of amplification by plodding their way through combinations of resistance, impedance, and transformer coupling, attempting to effect a compromise between the supposed quality of one system and the well-known high step-up ability of another. Or, at times, the search for perfection may have been tinctured with the desire for a combination which made use of apparatus already on hand.

Whatever the reasons for such combinations, they should be made only with some appreciation of the apparatus and its limitations. Many persons, for instance, wonder where in an a.f. system to place the audio transformer if only one is used. The answer to such questions can always be found. The method is simple.

Consider that the voltage step-up:

(1.)—in a 201-A is 8.
(2.)—in a 199 is 6.
(3.)—through a resistor-coupler is 1.
(4.)—through an impedance-coupler is 1.
(5.)—through a transformer is 2, 3, 3½, 5, or 6, according to the step-up ratio of the windings.
(6.)—through a high-mu tube (240 type) is about 20, or through any tube in a resistance- or impedance-coupled stage ought to be about two-thirds of the tube's mu (we have taken the effective step-up to be six in the case of a 201-A type tube).

This information is available in magazines, in catalogues, in tube instruction sheets, and in text-books. It allows one to engineer his a.f. amplifier with the employment of something akin to intelligence and the enjoyment of a feeling near that of competence.

As a preliminary to this engineering feat, choose some audio system you know to be functioning in a way that satisfies. As an example, let us use a two-stage amplifier with 3 to 1 and 6 to 1 audio transformers, a 201-A in the first

Read This Box First

THE signal voltage handling capacity of a tube used as an audio amplifier is governed by the amount of bias placed on that tube's grid. Thus, a 201-A type tube, with 4.5 volts bias (and the corresponding plate voltage of 90) will be overloaded and distort if called upon to handle more than 4.5 peak volts. The following table of C and B battery voltages for various tubes used as amplifiers will serve to make the author's article more complete:

Tube Type	B Volts	C Volts	Mu
201-A	45	1.5	8.4
	67	3	8.4
	90	4.5	8.5
	135	9	8.5
112	90	6	7.9
	135	9	8.2
	157	10.5	8.2
171	90	16.5	3
	135	27	2.9
	180	40.5	2.9
210	90	4.5	7.5
	135	9	7.5
	180	10	7.5
222	180	1.5	60

stage, and a 171 in the second stage, as shown in Fig. 1. The power tube is getting a B voltage of 180 and is properly biased so it is important to remember that its grid-swing limit is about 40 volts peak. To load the power tube, the second a.f. transformer must supply this 40 volts. We shall now determine the characteristics of an amplifier which will fulfill this requirement. For the second or the final audio transformer to give 40 volts, the grid of the tube in the first stage must be getting a voltage equal to 40 divided by the turns ratio of the transformer and the mu of the tube. The overall gain of the amplifier in Fig. 1 will be:

$$\underset{T}{3} \times \underset{Vt\,=\,201\text{-}A}{8} \times \underset{T}{6} = 144$$

Thus the requisite voltage at the output of the detector must be:

$$\frac{40}{144} = 0.28 \text{ Volts}$$

For sake of argument we shall accept this value of 0.28 volts as being average in future calculations. It has been the writer's observation, however, that many signals overload the 171 with an amplifier of this type, which would indicate that the output voltage of the detector sometimes exceeds 0.28 volts. This holds true for a set in Hartford, Connecticut, which, of course, is comparatively surrounded with high-powered broadcasters. If the detector will put out 0.56 volts, twice that calculated above, we can use a 3 to 1 transformer instead of the 6 to 1 transformer in Fig. 1 with somewhat better frequency characteristics.

Presuming that the a.f. amplifier will be satisfactory if up to the grid of the power tube it has a voltage multiplying ability of 144, the business of figuring equivalent combinations of resistance or other couplings is easy. For instance, in a three-stage resistance-coupled amplifier, such as is shown in Fig. 2, using 201-A tubes, the gain up to the grid of the power tube will be (bearing in mind that a resistor-coupler has a gain of 1 and that the actual amplification through the tube is about two-thirds of its mu):

$$\underset{Rc}{1} \times \underset{Vt\,=\,201\text{-}A}{6} \times \underset{Rc}{1} \times \underset{Vt\,=\,201\text{-}A}{6} \times \underset{Rc}{1} = 36$$

If the second tube has a grid bias of 4.5 volts

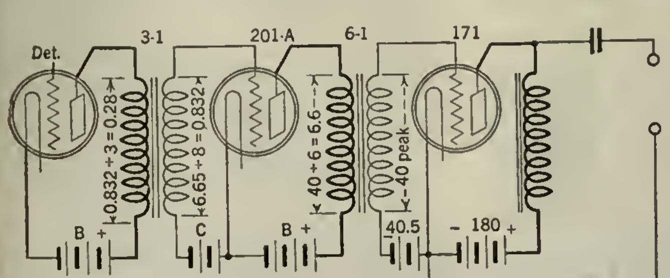


FIG. 1

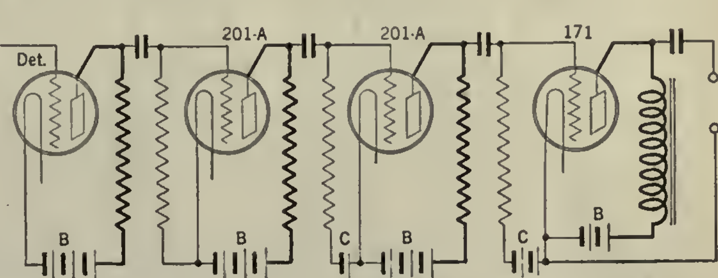


FIG. 2

and the correspondingly correct B voltage (in which case it should not be called upon to handle more than 4.5 volts signal voltage), it would be overloaded when required to handle the six volts which would deliver 36 a.f. volts to the grid of the final tube. This latter figure is not even enough to load up a 171 fully. The bias on the second tube could be increased, with correspondingly greater handling capacity, but this in turn would necessitate a higher B-battery voltage. It will be seen, therefore, that the second 201-A audio tube would be nicely loaded with a 4-volt grid-swing, in which case it would be able to supply the final tube with 24 grid volts. A 171 type tube with only 135 B volts and a C bias of 27 will be adequate to handle these 24 volts. With this amplifier the detector must output 0.67 volt (24 ÷ 36) to load the 171, which is quite a lot, if for no other reason than that local stations are likely to be necessary for so high a voltage. It will be agreed, then, that the usual resistance coupled amplifier with 201-A type tubes is not very satisfactory.

But suppose we use 240 type high-mu tubes with a working mu of 20. Here are the figures:

$$\overset{Rc}{1} \times \overset{Vt = 240}{20} \times \overset{Rc}{1} \times \overset{Vt = 240}{20} \times \overset{Rc}{1} = 400$$

The 240 will take a grid-swing of 3 (with 180 volts B, 3 volts C). It can overload a 171 on 180 volts if it gets more than 2 grid volts because 2 multiplied by 20 (the gain in the tube) is equal to 40, the maximum handling capacity of the 171. Hence, if three resistance-coupled stages are used, and since we have already decided that an amplification of 144 will satisfy for average conditions of detector output, the use of 240 type tubes is probably foolish. By dropping the plate resistor of the first tube to 100,000 ohms, the latter's step-up can be reduced to about 12. That would give an overall step-up of 240 to the grid of the last tube. A 201-A type tube in the first stage, with a step-up of only 6, will reduce the overall gain to 120, which begins to fit better with the desirable figure.

Now let us consider a single resistance-coupled stage. There has been a lot said about it in some of the more active sections of the press:

$$\overset{Rc}{1} \times \overset{Vt = 240}{20} \times \overset{Rc}{1} = 20$$

That is obviously no good. Why? The detector would have to output 2 volts in order to put 40 volts on the grid of the power tube. What about one resistance-coupled and one transformer coupled stage, such as that shown in Fig. 3?

$$\overset{T}{3} \times \overset{Vt = 240}{20} \times \overset{Rc}{1} = 60$$

It will be seen that the gain is insufficient in such a combination, too great a detector output being necessary. If, however, the transformer were a high-grade 6 to 1 unit instead of a 3 to 1 unit, the overall gain would be 120, which is much better.

Now let us consider the following three-stage a.f. amplifiers, shown in Figs. 4 and 5, in which

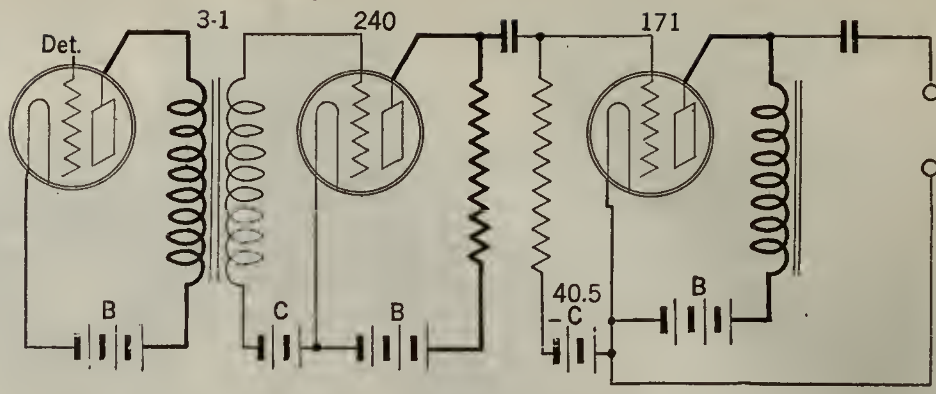


FIG. 3

the second audio tubes will handle about 4.5 volts grid voltage (since they are biased accordingly):

$$\overset{T}{3} \times \overset{Vt = 201\text{-}A}{6} \times \overset{Rc}{1} \times \overset{Vl = 201\text{-}A}{6} \times \overset{Rc}{1} = 108$$

$$\overset{Rc}{1} \times \overset{Vl = 201\text{-}A}{6} \times \overset{Rc}{1} \times \overset{Vt = 201\text{-}A}{8} \times \overset{T}{3} = 144$$

In the first case the next-to-the-last tube will be badly overloaded if the signal is strong enough to load a 171 to its maximum handling capacity of 40 grid volts. In practice, of course, the volume control on the receiver would be turned down as soon as overloading of the 201-A, manifest as distortion, became apparent, and thus the 171 would be working uneconomically. To deliver 40.5 volts to the 171 the next-to-the-last tube

the gain of the amplifier, the smaller the detector output voltage necessary to load up the power tube. Various three-stage combinations, with their overall amplification, are listed below. The necessary C voltage for the tubes may be determined by reference to the table on page 23.

$$\overset{Rc}{1} \times \overset{Vl = 240}{20} \times \overset{Rc}{1} \times \overset{Vl = 240}{20} \times \overset{Rc}{1} = 400$$

$$\overset{Rc}{1} \times \overset{Vl = 201\text{-}A}{8} \times \overset{T}{3} \times \overset{Vl = 201\text{-}A}{8} \times \overset{T}{3} = 576$$

$$\overset{Rc}{1} \times \overset{Vt = 201\text{-}A}{8} \times \overset{T}{2} \times \overset{Vl = 201\text{-}A}{8} \times \overset{T}{2} = 256$$

$$\overset{Rc}{1} \times \overset{Vl = 201\text{-}A}{8} \times \overset{T}{2} \times \overset{Vt = 201\text{-}A}{8} \times \overset{T}{3} = 384$$

$$\overset{Rc}{1} \times \overset{Vt = 240}{20} \times \overset{Rc}{1} \times \overset{Vl = 201\text{-}A}{8} \times \overset{T}{3} = 480$$

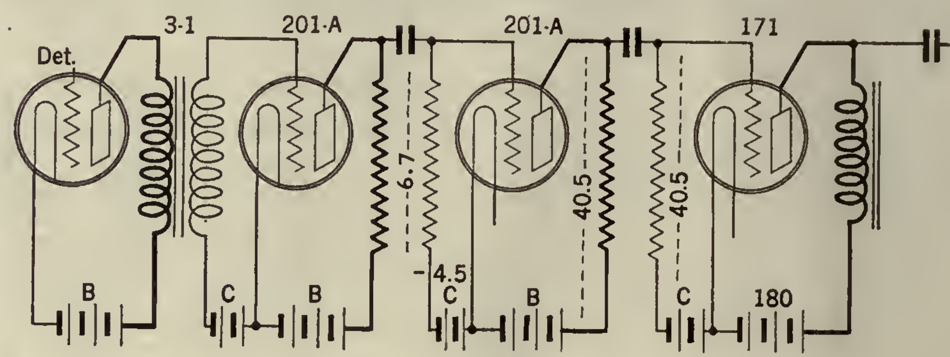


FIG. 4

has to handle 6.75 volts on the grid. If this tube were given a raise in bias to 9 volts with 135 plate volts, it would be capable of handling this voltage without overloading. Merely moving the a.f. transformer to the third coupling position, as in Fig. 5, requires that the second audio tube have a grid-voltage of only 1.68 to produce 40.5 volts on the grid of the power tube.

Judging from the fact that many set owners find two high-mu tubes highly desirable in a resistance—or impedance-coupled amplifier, the opinion that an amplifier step-up of 400 is sometimes useful, seems logical. Of course the higher

From all of the foregoing come a few useful rules, which may be outlined as follows:

(1.) In a combination of transformer-coupling with any other type of audio-frequency amplification the transformers should be in the last stages, and the transformer with the greatest step-up should be in the last one.

(2.) Always make certain that the tube before the power tube will not be overloaded before the power tube is fully loaded. To find this out is merely a matter of simple division or multiplication.

(3.) When judging the performance of two amplification systems, calculate what the overall step-up for each is before deciding what has happened.

There are other simple rules that it is good practice to heed. They may be stated as follows:

(a.) It is always best to require least of the detector. This is possible when the a.f. step-up is high.

(b.) High a.f. step-up is no help to the detector if the volume control follows the detector, and the less the step-up in the audio end the more this is true.

(c.) A detector gives greater undistorted output with increased B voltage, within limits. Operate it according to the needs of your set.

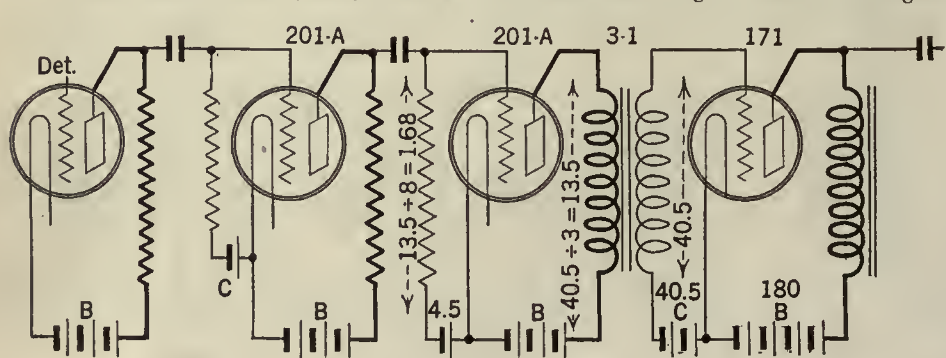


FIG. 5

The Month's New Phonograph Records

A $10,000 PHONOGRAPH-RADIO COMBINATION

The phonograph equipment is housed at the left and the radio at the right. The panel in the center contains a distortion meter (reading up to 150 mils.) and special circuit arrangements make it possible to control the amplitude of the sound by the top knob in this panel, while the control directly below it regulates overtones. The installation uses a four-stage balanced amplifier rated at 50 watts. Individual expression in the rendition of phonograph records or radio is said to be achieved through circuits arranged to vary both musical pitch and overtones without, at the same time, altering quality. This installation was especially built for La Salle & Koch, of Toledo, Ohio

TO THE great American query, "What's new?" we are forced to reply this month, "Not much." It may be merely an off-season for records. There were all too few likely looking titles in the advance lists. Perhaps the phonograph industry, like book publishing, blooms in full glory but twice a year and in-between-times puts out only a few pale buds. No, it isn't quite as bad as that because we did find nine records of such exceptional merit that they quite make up for the mediocrity of the rest. Among the classical output are several prize-winners: two duets by Gigli and De Luca, who can always be counted on to be worth while; two beautiful songs by Sigrid Onegin; choral work of outstanding quality by the Metropolitan Opera Chorus; and two instrumental numbers by the Columbia Symphony Orchestra. Of the popular stuff there are five better-than-average records. Ohman and Arden performing Gershwin music; Johnny Johnson and His Statler Pennsylvanians offering another Gershwin number and on the reverse one of the best songs from the Connecticut Yankee; a Paul Whitman masterpiece; two good numbers from the orchestra directed by the Maestro, known to the trade as Ben Bernie; and, lastly, a couple of unusual waltzes by the South Sea Islanders. The rest are so-so.

'S Wonderful and *Funny Face* by Victor Arden and Phil Ohman and Their Orchestra (Victor). Superb Gershwin music mixed well with Ohman-and-Arden piano magic and flavored with a bit of Johnny Marvin's best singing.

Thou Swell and *My One and Only* by Johnny Johnson and His Statler Pennsylvanians (Victor). Tuneful antidotes for that poisonous late-winter boredom.

Mary and *Changes* by Paul Whiteman and His Orchestra (Victor). Whiteman continues to glorify American jazz.

The Man I Love and *Dream Kisses* by Ben Bernie and His Hotel Roosevelt Orchestra (Brunswick). This record deserves a great big gold star.

I've Been Looking for a Girl Like You and *Everywhere You Go* by Paul Ash and His Orchestra (*Columbia*). For those who crave their jazz red hot.

Changes and *Let's Misbehave* by Ben Bernie and His Hotel Roosevelt Orchestra (Brunswick). Keeping up with the Bernie tradition of bigger, better dance music, with the emphasis on dance.

We'll have a New Home and *When You're With Somebody Else* by Ben Selvin and His Orchestra (Columbia). Standard fox trots of the snappy variety dressed up with fancy orchestration.

Tomorrow and *I'm Making Believe That I Don't Care* by the Colonial Club Orchestra (Brunswick). Just like countless other plaintive waltzes.

Girl of My Dreams I Love You and *Sugar Babe, I'm Leavin'!* by Blue Steele and His Orchestra (Victor). One more waltz and a noisy foxtrot with a raucous vocal chorus.

The Man I Love by Fred Rich and His Hotel Astor Orchestra (Columbia) A good song handled with no particular merit. *For My Baby* by Leo Resiman and His Orchestra. If your doctor has tactfully suggested that you do more exercising, get this record. You can't sit still to *this* number.

I Ain't Got Nobody and *Weary Blues* by Ray Miller and His Hotel Gibson Orchestra (Brunswick). Right you are! The first *is* an old number and what's more it is played in the old fashioned way with lots of brass and much pep. Of the second—the only thing that's weary must be the orchestra after it finishes.

When the Robert E. Lee Comes to Town and *I Scream, You Scream, We All Scream for Ice Cream* by Harry Reser's Syncopators (Columbia). If you haven't heard the words to the latter song the record is worth listening to—once.

Dawn and *We Two* by The Troubadours (Victor). Lewis James and Ed Smalle who manipulate the vocal refrains and the Troubadours have between them made a grand record out of two fairly good musical comedy numbers.

Among My Souvenirs and *Keep Sweeping the Cobwebs Off the Moon* by Abe Lyman's California Orchestra. (Brunswick). The treatment of the first is perfectly orthodox which means good. The second leaves us cold.

Away Down South in Heaven and *There's a Rickety Rackety Shack* by Frank Black and His Orchestra (Brunswick). (a) Even if this were good we wouldn't like it. Not with that vocal chorus! (b) Something else again; it's good!

That's What the Lei Said to Me and *The Call of Aloha* by the South Sea Islanders (Columbia). Waltzes that *are* waltzes.

Poor Lizzie and *I Love to Catch Brass Rings on a Merry-Go-Round* by Billy Jones and Ernest Hare (Columbia). a. The Happiness Boys sing out the old and sing in the new (Ford). b. Not very good nonsense.

More or Less Classical

Pescatore Di Perle—Del Tempio Al Limitar (*Pearl Fishers—In the Depths of the Temple*) (Bizet) and *Gioconda—Enzo Grimaldo, Principe Di Santafior* (*Enzo Grimaldo, Prince of Santafior*) (Ponchielli). Sung by Beniamino Gigli and Giuseppe De Luca (Victor). Week-day words are inadequate to describe the exquisite beauty of

Recommended New Records

Pescatore Di Perle—Del Tempio Al Limitar (Bizet) and *Gioconda—Enzo Grimaldo, Principe Di Santafior* (Ponchielli) sung by Beniamino Gigli and Giuseppe De Luca (Victor).

The Blind Ploughman and *The Fairy Pipers* sung by Sigrid Onegin (Brunswick).

Die Zauberflote—O Isis Und Osiris (Mozart) and *Chorus of Courtiers—on Mischief Bent* (Verdi), sung by the Metropolitan Opera Chorus (Victor).

Bridal Procession (Grieg) and *March of the Bojaren* (Halvorsen) played by the Columbia Symphony Orchestra. (Columbia).

'S Wonderful and *Funny Face* by Victor Arden and Phil Ohman and Their Orchestra (Victor).

Thou Swell and *My One and Only* by Johnny Johnson and His Statler Pennsylvanians (Victor).

Mary and *Changes* by Paul Whiteman and His Orchestra (Victor).

The Man I Love and *Dream Kisses* by Ben Bernie and His Hotel Roosevelt Orchestra (Brunswick).

Jupiter Symphony (No. 41, Op. 551) (Mozart) by the State Opera Orchestra of Berlin, conducted by Richard Strauss. (Brunswick).

these duets as sung by this baritone and tenor from the Metropolitan Opera Company.

The Blind Ploughman (Radclyffe-Hall-Clarke) and *The Fairy Piper* (Weatherly-Brewer) sung by Sigrid Onegin (Brunswick). An organ accompanies this rich contralto voice in the first selection and reflects the seriousness of the song. In the second selection the tinkling notes of a piano and a flute illustrate the fairy music of which Miss Onegin sings delightfully as well as capably.

Lucia: Sextet—Chi raffrena il mio furore (*Why do I my arm restrain?*) (Donizetti) Sung by M. Gentile, D. Borgioli, G. Vanelil, S. Baccaloni, G. Nessi, I. Mannarini and chorus. (Columbia). This imported recording does not do full justice to the famous musical race in which the soprano is foreordained to win. The volume is, for one thing, too great. On the reverse is *Somnambula: D'un Pensiero* (*No Thought but for thee*) by M. Gentile, D. Borgioli, I. Mannarini, G. Pedroni and chorus, which is excellent except for the thinness of the soprano voice.

Die Zauberflöte—O Isis Und Osiris (*The Magic Flute—Chorus of Priests*) (Mozart). Sung by the Metropolitan Opera Chorus with the Metropolitan Opera House Orchestra under the direction of Giulio Setti. (Victor). This splendid organization presents a very plausible chorus of priests who are evidently all superior musicians. And the very next moment (on the reverse of the record) they are equally convincing as a *Chorus of Courtiers—On Mischief Bent* (*Scorrendo Uniti Remota Via*) from Verdi's *Rigoletto*.

My Message and *Nocturne* by John Charles Thomas (Brunswick). The same glorious baritone—and you *may* like the ballads.

Quartet in G Minor Second and Fourth Movements (Debussy). Played by the New York String Quartet (Brunswick). All the tricks of the string trade are herein utilized to demonstrate the beautiful and varied effects obtainable by two violins, a viola and a cello.

Bridal Procession (Grieg; Op. 19, No. 2) and *March of the Bojaren* (Halvorsen). Played by the Columbia Symphony Orchestra under the direction of Robert Hood Bowers (Columbia). This delightfully gay and lighthearted bridal chorus must have been written for a fairy wedding; mortals take their weddings more tearfully. And here is a march that is not impressed with its own importance but is quite willing to be exuberant and even humorous. But then a march scored for strings, and woodwinds as well as for brasses can present these characteristics more easily than can the fife and drum brigade. The Columbia Symphony handles both these numbers with ability.

All Hail the Record Albums

IT IS just another miscarriage of justice that somewhere in these United States there walks a man, unheralded and unsung. The man in question is the inventor of the album set. Until he sold his idea to the phonograph companies (we *hope* he sold it; if he can't have fame he should at least have royalties) our record library contained only *selections* from operas, *gems* from operettas, arias, ballads, folk songs, bits of this, and bits of that. No extended work could be had in its entirety because, alas, it could not be fitted on to the limited space afforded by a rubber disc, and it had never occurred to the phonographers to distribute one work of art over several discs, selling them as one unit. Now, however, we have whole symphonies, tone poems, and concertos, complete from the first note to the last. They come on several records, neatly stowed away in good looking albums, and accompanied by explanatory booklets which invariably are excellent and useful. These musical works are recorded by the best talent available in this country and in Europe and the technical work of putting the notes on the wax is done so expertly that no iota of tone is missing, no shading is lost.

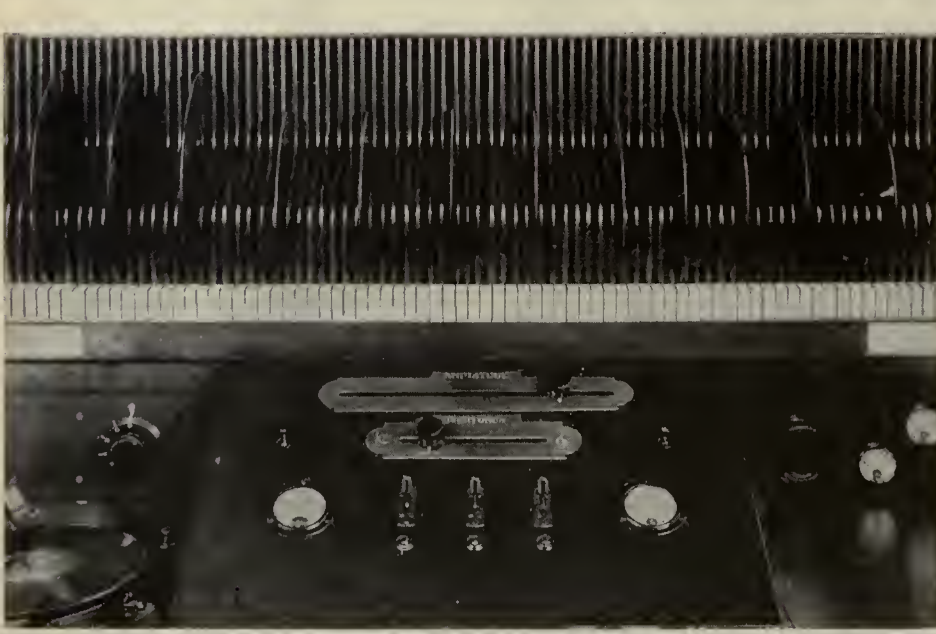
In the March RADIO BROADCAST appeared a partial list of the music available in album form. The list is growing daily.

Mozart's "Jupiter" Symphony

WE HAVE already reviewed one album set, the *Scheherazade Symphonic Suite* by Rimsky-Korsakov, played by the Philadelphia Orchestra under the direction of Leopold Stokowsky, and recorded by Victor. This month we praise another symphony, equally beautiful in an entirely different way, the *Jupiter Symphony* (No. 41, Op. 551) of Mozart, played by the State Opera Orchestra of Berlin, conducted by Richard Strauss, recorded in Europe for Brunswick. It covers two sides of three records and one side of a fourth, the remaining surface being given over to the *Turkish March* (Mozart-Cerne) played by Vasa Prihoda. The Rimsky symphony is full of color, warmth, and emotion. It conjures up pictures of the Orient with its glowing colors, shimmering light, sinuous maidens, swaying camels, dancing fakirs, and the spicy smells of the market place—all the kaleidoscopic romance of the East. Mozart's symphony, on the other hand, brings forth no pictures. It lacks the warm humanity of the Russian music, lacks its emotion, lacks its color. But it has something which takes the place of these qualities, a precise musical style. It is music as pure, unsullied, and crystal clear as water bubbling from a spring on a mountain side. It is melodious from start to finish for Mozart was an expert harmonist. He lived his short life (1756–1791) at a time when emphasis was placed on form and harmony. The symphony was a fairly recent development. It had evolved gradually from the overture, the instrumental introduction to an opera, and had been given a more or less standard form by Haydn who was born twenty-four years before Mozart. This form consisted of three or four movements, generally four. The first and fourth were the longer and more essential, and were brisk in tempo. The second was slower and eminently lyrical, and the third usually a sprightly minuet. This is the form used by Mozart in the *Jupiter Symphony*. The orchestra for which he scored the symphony consisted of one flute, two oboes, two bassoons, two horns, two trumpets, kettledrums, and strings, and for the second movement he reduced it by the omission of trumpets and drums. This is a much smaller organization than the symphony orchestra of to-day.

It is particularly in the fourth movement, the loveliest of them all, that Mozart displays his technical skill, but not ostentatiously. The beauty and spontaneity of the music conceal the learning which is its foundation. The design of the movement is a combination of the sonata form and the fugue. The sonata form is that used for first movements of symphonies and consists of three parts, the Exposition which sets forth the themes; the Development which embroiders the themes; and the Recapitulation which restates the themes. In this movement Mozart uses four distinct musical ideas. The first is given out at once by the violins, its four opening notes being an ecclesiastical melody of which Mozart made frequent use. A second, and gayer, phrase follows this; the subject is then repeated *forte* by the full orchestra and at the end of the passage the second idea is introduced by woodwind and strings. There are sixteen measures of this, filled with exuberant tone. Next there is a return to the church theme treated in the orthodox fugal manner. At length this same theme is taken up *forte* by the full orchestra and at the fourth measure of it there is heard, in the first violins, the third idea. After a repetition of the second idea, the fourth idea—the second real theme—appears in the strings.

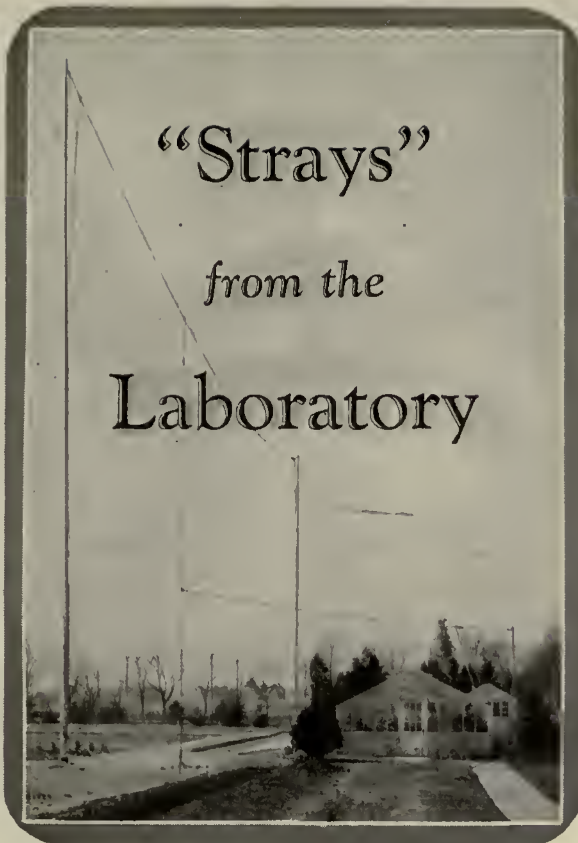
From this brief analysis of the last movement of the symphony you can perhaps derive some idea of the intricacy of the framework on which Mozart weaves his beautiful melodies. You will love these melodies whether or not you understand the construction, but if you follow the mechanics of the symphony you will arrive at a more complete understanding and consequent appreciation of the composition.



A CLOSE-UP OF THE CONTROL PANEL

A bank of three loud speakers is used with this phonograph-radio combination. Each loud speaker circuit has its own distortion meter, with controls permitting each circuit to be operated at its own regulated volume. Circuits and apparatus are provided so that the operator can announce the selection to be played through the entire loud speaker system

"Strays" from the Laboratory



Detector Distartian

Many times we have read about radio receivers so engineered that the detector did not overload, or receivers in which the detector did overload, or some other reference to distortion due to detector overloading. This leads us to ask such questions as: When does a detector overload? What does the output sound like when such overloading occurs? Is it true that a C bias detector will handle much larger input voltages without overloading? If so, how much? The answers to some of these questions are being sought in the Laboratory, and as fast as the material is ready it will be presented in these columns.

In the meantime, one of our friends has determined, empirically, that the average detector begins to overload when the detector delivers about 15 TU below 1.0 milliwatt. What does all this mean, you will ask?

Let us suppose that a detector has an output impedance of 30,000 ohms and that it works into a load of this impedance, say a resistance or a transformer of proper characteristics. Fifteen TU below 1.0 milliwatt is equal to about 0.03 milliwatts, or about 30 microwatts. What voltage across 30,000 ohms will deliver this amount of power? This is the useful voltage, for it is what the amplifier boosts in value so that the final power tube in the system will deliver its rated output. This voltage may be found by extracting the square root of the product of the power by the resistance. Or.

$$E = \sqrt{Wo \times R} = \sqrt{0.03 \times 10^{-3} \times 30{,}000} = 1 \text{ volt}$$

(approximately)

Therefore, a detector which will deliver 30 microwatts to 30,000 ohms without overloading will produce 1.0 volt across the input to the amplifier. It now remains to prove under what conditions the detector will fulfill these expectations, and when overloaded, how the average experimenter can tell it by the sound of the output.

Has any reader experience in this matter?

A Short-Wave Adapter

The following letter apropos of short-wave experimental broadcasting and its reception is interesting: It comes from C. R. Strange, of Sydney, Australia. "On the page 'Our Readers Suggest' in the December Radio Broadcast, there is described 'A Short-Wave Converter for any Radio Receiver' by Perry S. Graffam.

"It will be of interest to your readers to know that out here in Australia we appreciate your journal and that several days ago I built this adapter to plug into my Grebe Synchrophase which was presented to me by the A. H. Grebe Company of Richmond Hill, New York, following my reception of their station, WAHG, on 314.5 meters.

"An hour after I had finished Graffam's adapter I was listening to the transmission from 2 LO (London) through the short-wave station 5 SW Chelmsford England, on 24 meters, using the two audio valves of the Synchrophase receiver and my model-100 loud speaker. On the 25th (January) I listened wonderfully to this station for 55 minutes, the volume being audible some 15 feet from the speaker. Also on the 25th and last night I listened also with wonderful success; here, some 13,000 miles away, it is rather thrilling to listen to London broadcasting at midday such items as selections from Cavalleria Rusticana, Percy Grainger's pianoforte arrangements, Carmen, and a fine tenor voice singing 'The Sargent Major's on Parade.'

"We surely are in a wonderful age. Televison will be the next thing for Australia."

Short-Wave Broadcasting

There have been numerous attempts to convince the public and, we imagine, the Radio Commission as well, that broadcasting should take place on the high-frequency (short-wavelength) bands. Let us look only at the problem of keeping a station on its assigned frequency which, for sake of argument we shall assume to be 10,000 kc., or ten million cycles. Many broadcasters are having difficulty in keeping their present transmitters within one-half kc. of their assigned frequency. What would be their troubles if they worked at 30 meters? Five-hundred cycles in 10,000,000 represents an accuracy of one part in 20,000, or five-thousandth of one per cent. At the present time, a station operating on 1000 kc. must keep its assigned frequency to within 500 cycles in one million which represents one part in 2000 or five-hundredths of one per cent. In other words, it would be about ten times as difficult to keep a station on its frequency at 30 meters as it now is at 300 meters.

We understand the Navy builds short-wave equipment that must be accurate to within 100 cycles at 30,000 kc. That is, they build a transmitter to this specification, and a receiver to go with it and the sum of their percentage inaccuracies must not be over 200 cycles in 10 million, or 100 cycles for the individual unit. This represents an accuracy of one part in one hundred thousand, or one ten thousandth of one per cent., an accuracy 50 times as great as that required of stations now operating within the broadcast band. These Navy units, it should be noted, are designed for code transmission and reception.

The "Equamatic" System in England

Radio Broadcast takes pride in quoting part of a letter from Louis G. King, whose system of tuning, known as the Equamatic System, was first described in this magazine. Mr. King has just returned from Europe and that his trip was successful may be surmised from this part of his letter: "Recently we have entered into an agreement with Graham Amplion, Ltd., for the production of the Equamatic System in the British Isles. After carefully testing radio receivers produced by the leading manufacturers in all parts of the world, Graham Amplion, Ltd., adopted the Equamatic System." The system has, in this country, been most closely associated with receivers designed by the Karas Electric Company.

Finding Ore by Radio

Many times in the past year or so, the editors have been asked to forward information on devices useful in finding ore or hidden treasure by radio. Up to the present time it has been impossible to give any authentic information regarding such apparatus, and therefore, we are appealing to the readers of the magazine. What is wanted is information on methods and apparatus used, whether using radio or other electrical apparatus, results secured, and articles published whether in this country or abroad. This will enable us to help prospective treasure hunters toward a financially successful jaunt.

Real Pawer fram twa 112's

Radio listeners in communities where there is no a.c. power available need not feel that it is impossible to secure sufficient power to operate their loud speakers properly just because they cannot tap the house lighting system and get high voltages and considerable plate current therefrom. For example, two 112-A tubes will deliver considerable power without excessive plate voltage or current—which means that the farmer who has no power equipment may secure good quality and plenty of loud speaker power from B batteries, and do it economically. The table below shows the relative power output and necessary grid a.c. voltage to deliver this power from a single 171 or two 112's in parallel. Note that two 112's in parallel with 157 volts on the plate require 16 milliamperes from the B batteries and deliver 400 milliwatts of power to a loud speaker on only 10.5 input grid volts while a 171, taking the same current from 135 volts, requires a grid voltage of 27 to produce 350 milliwatts. Two 112's in parallel will have an output impedance of about 2500 ohms which will work very well into the average loud speaker:

Tube	Ep	Ec	Ip	Watts Output
171	90	16.5	11	.12
	135	27	16	.35
	157	33	18	.50
	180	40.5	20	.65
2—112's	90	4.5	8.0	.08
	135	9.0	11.6	.240
	157	10.5	16.0	.400

Tested Products

Some tubes from Sylvania Products Co., have been measured in the Laboratory recently. The values given below are the average of six of each type of tube:

Type	Ip	μ	Rp	Gm	Ep	Eg
201-A	2.2	9.2	12330	750	90	−4.5
112-A	7.0	7.5	5160	1450	135	−9.0
171	19.0	2.9	2240	1300	135	−27.0

The Screen-Grid Tube: Selectivity

Experimenters who have installed a single screen-grid tube ahead of a detector, regenerative or not, have been disappointed at the apparent loss in selectivity of the system, although the gain increases. Let us suppose that the resonance curve of a single-stage of r.f. amplification using a 201-A tube is as shown in Fig. 1. Now let us use a screen-grid tube in which the gain may be twice as great. In other words every point of the resonance curve of Fig. 1 is boosted twice as high with the result as shown in B. In any local area, stations are separated by 50 kc., so that on Curve A the incoming signals from a station 50 kc. off resonance are below the line which represents the arbitrarily chosen signal magnitude beyond which interference occurs. Now look at Curve B. Here the 50-kc. signal is up out of the area in which no interference occurs, and is heard in the background of the station to which the receiver is tuned.

Let us call the absolute selectivity factor, the ratio between the height of the curve at resonance to the height at 50 kc. off resonance. This factor for curve A is 50 ÷ 2.4, or 2.1, and for the curve B is 100 ÷ 4.8, or 2.1 exactly the same. Then, if the apparent selectivity is defined as the number of kilocycles off resonance a signal must be before it is reduced to the non-interfering region, we see that for the 201-A example it is 50 kc. while for the Curve B where the gain is twice as great the frequency is 70 kc. These figures depend, of course, upon the shape of the resonance curve.

Each additional stage of 201-A r.f. amplification increases the gain of the receiver and increases the selectivity, but as Professor Hazeltine has shown in his recent patent, No. 1, 648, 808—(Nov. 8, 1927)—by properly designing the interstage transformers in such amplifiers, an increase in selectivity of 50 per cent. can be obtained at a loss of only 20 per cent. in amplification. In other words, in a system using successive tuned stages, relying upon resonance curves for selectivity, there must always be a compromise between gain and selectivity. Increasing the gain without increasing the absolute selectivity at the same time, reduces the apparent selectivity. Although the signal to which the system is tuned will be louder, so will the background produced by other stations.

Adding a single stage of screen-grid tube r.f. amplification under conditions which produce maximum gain from that tube, decreases the apparent selectivity too much. Adding an extra stage, from which we secure maximum amplification, will boost the sensitivity faster than the selectivity is increased, and we are no better off than before.

In other words, if three stages of 201-A amplification are needed to secure sufficient selectivity, more than three stages will be necessary when using screen-grid tubes. This seems to indicate that these tubes will not decrease the number of effective tubes in a receiver, but will actually increase that number—so long as we use the t.r.f. system of tuning.

The answer, if this reasoning is correct, is to use a different system of tuning. The superheterodyne is one solution; perhaps the Vreeland system described recently in the I.R.E. *Proceedings* is another. This is a system designed with the avowed intention of making a response curve of a receiver flat on top and very steep on the sides. It is done by using two closely coupled circuits so that the resonance hump is not a single sharp peak, but is composed of two peaks with a dip between. The Laboratory hopes to present some quantitive data on this system soon, and in the meantime welcomes comments on the problem outlined above.

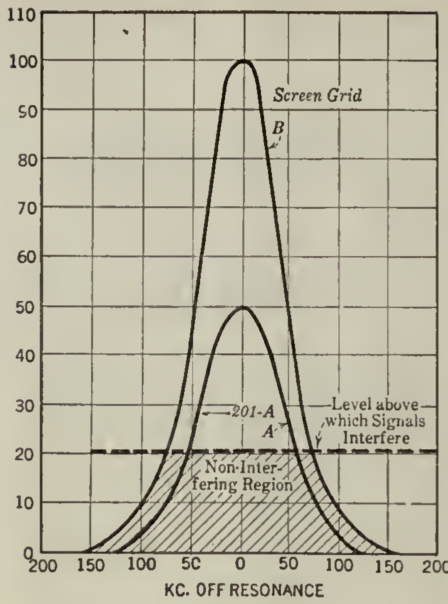


FIG. 1

Loud Speakers

Many times per month we hear about some high official in this or that radio company who indulges in a bit of forecasting, usually about the future of radio. Among other trends, to believe these officials, is that toward greater power which will be handled in the future radio's amplifier, one executive going so far as to state that our sets of the future would have amplifiers turning into our loud speakers at least ten times as much energy as they do at the present time. Judging from what has happened during the past few years, one cannot doubt it, for in the good old days we were satisfied with the output of a 199, then we needed a 201-A to deliver sufficient power, then the 112, then the 171 and 210 tubes, and now the 250 type. Each of these tubes delivers considerably more power than its predecessor, and to jump from a 5-watt tube to a 50 watter represents ten times as much power output, that is, 10 TU difference.

We are not convinced. Several years ago we listened to a pretty fair program coming from a speaker that was 10 TU better than any speaker now generally available. That is, it required 10 TU less power to get a good healthy sound from it. This represents the difference between a power output of 600 milliwatts (171-A), and 60 milliwatts (201-A). In other words, when loud speaker manufacturers are able to build a loud speaker with a good characteristic that is 10 TU better than our present loud speakers, we can all go back to our old 201-A tube, our B batteries, and start all over again.

What are the prospects? We have heard that the Western Electric Company builds a loud speaker much more efficient than the 540-AW, for sale in England only. It does not have the same tonal range as the 540-AW and is cited only as an example of an efficient loud speaker.

Incidentally, present trends in loud speaker design are toward moving-coil affairs, electrodynamic units, such as the Magnavox and the Jensen cones, and the Vitaphone, which is a moving-coil unit, coupled acoustically to an exponential horn. All of these have very fine frequency characteristics, with honors at this writing in favor of the Jensen. The Jensen is made in California and is now generally available, we understand. We have seen curves, above reproach, which show the Jensen to have a quite flat response curve from about 60 to 6000 cycles. With a large baffle-board, such as obtained by inserting the loud speaker in the walls of a home, the lower limit of response can be pushed down to about 35 cycles. A six-foot square baffle about one and a half inch thick, is however, very satisfactory.

If this Jensen unit, for example, could be made 10 TU more efficient, that is to say, deliver the same output with one-tenth the input, the result would be distinctly worth achieving. It should not be forgotten, however, that aside from the question of overall "audio" efficiency in this unit, we must supply the coil with 60 mils. at 100 volts—6 watts of power.

The Magnavox, too, is a fine product, but seems to suffer from excess filters which appear to be necessary to prevent too much a.c. hum from getting into it, to cut down the high-pitched heterodyne whistles, and other noises. In other words, a Magnavox loud speaker unit without the removable devices now employed to make up for our present poorly filtered a.c. receivers, or the present unfortunate situation in the ether, is a fine unit.

We understand from an unimpeachable authority that the Stromberg-Carlson engineers built into stock receiver models a few years ago, audio amplifiers so good that nearly all of them came back. Criticism arose from the fact that these receivers seemed more noisy than sets of other manufacturers; more static came in, and "whistles" were more evident. It was a simple matter at the factory to put filters in the amplifier system, cutting down on the two ends of the frequency spectrum. Then the receivers stayed sold. It is a fact that many hundreds of these receivers have been sold to Bell Laboratories engineers and their friends. As soon as they are received out comes the soldering iron, off comes the filters, and out of the loud speaker come the low and high frequencies that are so essential to good quality.

Watch for the A. C. "Lab" Receiver

Hugh Knowles' article describing the construction of the popular R. B. "Lab" circuit for a. c. operation will appear in Radio Broadcast *for June. The completed receiver has been thoroughly tested in* Radio Broadcast *Laboratory and has proved very satisfactory indeed. Readers will recall the complete experimental article in our April number describing tests in the Laboratory on the design of this circuit. The June article describes completely the construction of an a. c. four-tube "Lab" circuit receiver. Some of its interesting features are: Excellent efficiency for four tubes: a. c. operation, an extra socket and control switch enabling quick transfer of the audio system to phonograph pick-up or short-wave tuner unit, and an interesting volume control.*

—The Editor

An Error in Coil Dimensions

In the article on the four-tube "Lab" receiver in the April Radio Broadcast, specifications were given in Fig. 2 for coil dimensions. Coils L_1 and L_2 were shown to consist of 90 turns, No. 24 s.c.c., on a form 2.5" in diameter. The correct designation should have been 90 turns No. 24 s.c.c. on a 2.0" diameter form. If the reader already has a 2.5" coil form, he may use 66 turns of No. 24 s.c.c. wire to cover the same range.

—Keith Henney.

The Listeners' Point of View

HOW TO IMPROVE BROADCASTING

By JOHN WALLACE

IN THE January number we unburdened our soul of some ingrowing and irate convictions in an article, "Are Radio Programs Going in the Wrong Direction?" They were, we said, and the general tenor of our hymn of complaint may be recalled by quoting: "Whatever roseate promises radio may have seemed to have held in the past, we are at present thoroughly convinced that things have reached a sorry pass, and that radio is standing still — smug, self-satisfied, and unutterably banal. . . . In fact standstill is putting it mildly; the state of affairs is more exactly a retrogression. All the money, all the ingenuity, all the labor that is being devoted to the designing of programs is being diligently devoted to efforts in the wrong direction — with the result that radio is going to the dogs at a breakneck speed, so rapidly, in fact, that to check it will require no little effort."

During the four months which have elapsed since publishing this diatribe we have had an unusual number of communications, ranging all the way from heartiest endorsement to bitterest denunciation.

One commentator says: "The writer is one of those humans who inordinately admires a 'kicker' if, and when, said kicker registers his kick with some accuracy and a lot of éclat. That is preparatory to a 100 per cent. endorsement of your kick in the January Radio Broadcast—'Are Radio Programs Going in the Wrong Direction?' Every word in this article is pregnant with common sense and as true as Gospel." (Such perspicuity! *J. W.*)

Another correspondent states: "You are just like all the rest of the tribe of critics—'smug and self-satisfied.' What good do you expect to effect by such destructive criticism as is contained in your article in the January Radio Broadcast? Here thousands of people throughout the country have been putting in eight hours a day for the last five years to make radio what it is today and then you come along and in an article that couldn't have taken two hours to write, presume to set at naught all this accomplishment." (O my, O my, it sometimes takes us twenty hours to write one of these! *J. W.*)

Such was the run of lay comment. We quote two other replies, both from members of "the profession." These retorts were not addressed directly to us but were forwarded to "Pioneer" of the New York *Herald-Tribune* who quoted our unkind remarks in his column. One is from the president of two small stations and the other from the president of the National Broadcasting Company. Mr. Donald Flamm, president of stations WMCA and WPCH, in a lengthy open letter said, among other things:

"It is to answer Mr. Wallace, as well as the radio critic through whose courtesy Mr. Wallace's remarks were presented, that this is written. I don't propose to speak for all the broadcasters. I am simply giving my own opinion, based upon three years of association with the radio industry and particularly with the broadcasting end of the business. . . . I, too, have come to the realization that radio is at a standstill and . . . it is not within the province of the radio impresario to do very much about it. And, furthermore, it is going to remain at a standstill unless some very remarkable change occurs in the very art of radio broadcasting itself—a change that is entirely beyond our control. . . . Let us consider . . . the plight of the broadcaster.

"He can appeal to his audience only through sound—nothing else. . . . There is nothing in the world he can add to his 'tools' with which to accomplish so-called showmanship. There is another angle that we cannot overlook . . . the fact that the broadcaster is constantly doing something different. In writing a play, the author takes weeks and sometimes months . . . the stage director continues the job and shapes and changes the play . . . until it is finally ready for a long, or perhaps a short, run on Broadway. The same play is repeated performance after performance without the slightest variation of a line or a movement. The author's job is done, the director's job is done, the producer's job is done. How different is the task of the broadcaster! Every program must be different. And as in the case of WMCA, which goes on the air at 9 o'clock each morning and continues broadcasting right through the day and evening until sometimes as late as 2 A. M., what opportunity have we for observing these rules of 'showmanship'?

"After all, what is there that we can present to the public that will display good 'showmanship' and 'intelligence'? Radio impresarios have presented almost every great living artist available. There is not a musical organization in the country whose services have not been utilized at some time or other. During the course of the year we have also presented hundreds of orchestras, numerous celebrities from all walks of life, interesting and informative talks by competent authorities, vaudeville programs, short programs and long programs; in short, we have availed ourselves of every possible form of entertainment. We have not left a stone unturned in our effort to bring to our audience the complete range of program material. Beyond that we can do no more."

Mr. M. H. Aylesworth, president of the National Broadcasting Company said, in part:

"I have read with considerable interest the various criticisms of broadcasting programs . . . which you recently quoted in your interesting column. It has occurred to me that a short résumé of the talent which has been made available through the system of the National Broadcasting Company and associated stations by American industries who are sponsoring national programs, as well as those produced by the National Broadcasting Company, and associated stations in the last sixty days (January and December), shows something of the vast undertaking in arrangement and finance to make possible the feasible reception of these speakers and artists by the American radio public." The résumé, which is entitled "A Partial List of Outstanding Broadcasts by the National Broadcasting Company," is given herewith:

Artists, actors, and actresses—Ernest Hutcheson, Percy Grainger, Ohman and Arden, Irene Scharrer, Ethel Leginska, Robert Armbruster, Ignace Friedman, Herbert Carrick, George Gershwin, Josef Lhevinne, Adam Carroll, Richard Rodgers, J. Milton Del Camp, Richard Buhlig, Benno Moiseiwitsch, and Mme. Wanda Landowska, pianists; Mischa Weisbord, Paul Kochanski, and Arcadie Birkenholz, violinists; Ethel Hayden, Van and Schenck, Katherine Meisle, Editha Fleischer, Reinald Werrenrath, Maria Kurenko, Marie Tiffany, Elsie Baker, Arthur Hacket-Granville, William Simmons, Mary Lewis, Armand Tokatyan, Ann Mack, Mary Garden, Al Jolson, John Charles Thomas, Emilio de Gorgoza, Merle Alcock, Mario Chamlee, Duncan Sisters, Tita Ruffo, Fanny Brice, Claudia Muzio, Cliff Edwards, Rosa Ponselle, Giovanni Martinelli, Ezio Pinza, Richard Crooks, and Sophie Braslau, singers; "Chick" Sale, Joe Cook, Dr. Rockwell, Fred and Dorothy Stone, Leo Carilla, Weber and Fields, and Cornelia Otis Skinner, actors.

Orchestras and orchestra leaders—Walter Damrosch, conducting the New York Symphony Orchestra; Fritz Busch, guest conductor; Roderic Graham, conducting G. M. Symphony Orchestra; Patrick Conway and band, Edwin Franko Goldman and band, Paul Whiteman and orchestra, Vincent Lopez and orchestra, and Ben Bernie and orchestra.

Authors and explorers—Robert Benchley, Will Rogers, Irvin S. Cobb, Ford Madox Ford, Louis Golding, Glenway Westcott, Louis Bromfield, Commander George Dyott, Fannie Hurst, Helen Hull, Elmer Davis, Cosmo Hamilton, S. S. Van Dine, Dr. Ralph Sockman, John B. Kennedy, Homer Croy, Grantland Rice, and Bruce Barton.

ARGUMENTS FOR THE DEFENSE

IN VIEW of the foregoing we have a defense of our January remarks, and an enlargement of them.

To those who objected that our stand was destructive, our retort is: It wasn't. We claim, constructively, that serious instrumental music should be the backbone of radio entertainment. We offered no constructive suggestions as to what should make up the balance of programs, not because we had no ideas on the subject but simply because of lack of space. Specific ideas along those lines follow.

As for Mr. Aylesworth's reply—sorry, but we're going to quote again from the January squawk: "What is the right direction for program making to take? Program makers are too embroiled in their business to glance at the guideposts, too pressed by the strenuous and unceasing job of making programs to take a moment or two off for a little rational reflection on what their job is all about. They persist in refusing to take account of the fact that radio is a new medium, a unique medium and, like any other medium, endowed with its peculiar limitations and peculiar possibilities. Pig-headedly, they persist in attempting to reconcile with their duties the traditions of the drama, the opera, the music hall, and the vaudeville stage."

In view of these remarks Mr. Aylesworth's rebuttal is seen to contain its own refutation. All the individuals he mentions are recruited from "the drama, the opera, the music hall, and the concert stage." However, we will not gloat over Mr. Aylesworth's self-confounding; our victory is merely a dialectic one. For the fact is that the programs he mentions *are* the very best that are at present discoverable on the air.

But it is unfortunate that this is true for such programs represent not progress, but stand-

still. They are good in their way, but they remain a makeshift, a borrowing. Multiplying them to the *n*'th degree would still be doing nothing to serve the ultimate ends of radio as a permanent institution. Radio must develop its own artists, actors, actresses, and orchestras. These may also do work in the other field but they must be first of all radio performers. What Mr. Aylesworth lists is not *radio performers* but names. names, names.

Mr. Flamm, quoted above, agrees with us—but—we do not agree with him. Our version of the predicament was not pessimistic. His is. We claimed that nothing was being done to get radio out of its rut. He claims that nothing can be done.

THE BROADCASTER CAN'T IMPROVE BROADCASTING

THERE the broadcaster—if Mr. Flamm can be taken as representative—lays all his cards on the table and discloses himself for what he is—an unimaginative soul who isn't fitted to guide his own destinies. He laments that the broadcaster can appeal only through sound. He should rejoice. Sound. There is his medium—plainly and unmistakably identified. There are half a million sounds in existence awaiting his use of them. Obdurately he ignores them. The conclusion toward which we have been laboring should by now have made itself manifest: *the broadcaster can't improve broadcasting.*

If broadcasting is to be extricated from the rut of dull routine in which it finds itself, it is evident that the help must come from without.

Why? The reason is plain enough. The broadcaster is first of all a business man—an impresario. If he transcends that he may, in some instances, be also an interpretative artist. But by no stretching of the imagination can he be regarded as a creative artist. Nor are the gents on his staff of continuity writers likely to be creative artists. Creative artists are rare birds and not likely to be found among the hirelings of a big industry. The result is that nothing is being created for radio; without creation no art can come into being—including radio art.

True, there are program makers who go through some of the motions of creating. But they haven't got the goods in them and what finally results is merely a banal, or at best "tricky" arrangement of a lot of old stuff.

The broadcasters, however, have no occasion to resent this indictment of their artistry. We wouldn't have them artists! Imagine what would happen to the National Broadcasting Company if a crew of long haired birds should try to run it. It would go out of business in three days. The broadcasters are marvels of efficiency in their own field. They have effected the most rapid growth that any industry has ever known. All honor is due them. The only trouble is that they are trying to extend their field outside of its legitimate limits. Impresarios, well and good; but creators—phooey!

Now the truth of the matter is that there is an Art of Broadcasting. The only trouble is that it hasn't been discovered yet. There have been inklings and foreshadowings of what it is to be. But these foreshadowings, though they're as obvious as the nose on your face, have been practically ignored. To mention a couple of these harbingers, one was the Eveready Hour's "Galapagos" and the other was that same organization's "Show Boat."

These two programs came at least nearer than any others to demonstrating what the new radio art form will be like. But excellent as they were they only faintly suggest the unexplored possibilities of what we hereby dub "Sound Drama."

We don't propose to write you a "Sound Drama." In the first place that's not what we're hired to do, and in the second place we haven't the necessary talents to do it. But it is within our rights and powers to prophesy what the so far unwritten "Sound Drama" will be like. It will be a little like the Stage Drama. It will be a little like the Opera. It will be a little like the Symphony. It will be a little like Literature. It will be a little like the Oratorio. And it will be exactly like no one of these. What it will be is the perfect synthesis of all the modes we have mentioned. Which also means it will be quite a chore in the making! No ordinary ham is going to be able to take all these art forms and weld them into a whole which will be not merely a conglomeration but a unity, an art form in itself. It is a task for a creative artist of the highest ability and originality. The artist who does it will have to be Playwright, Composer, and Poet all at once—in other words such a man as was Richard Wagner. He need not be technically equipped in each one of these fields of art. But his taste, at least, must direct the efforts of collaborators to a unified end. (It is needless to add that he must also familiarize himself with the mechanical limitations of radio transmission and adapt his music and all else he offers to these requirements.)

The time is now ripe for the new art to appear, for the radio lords have brought radio up to the point where it is susceptible of being made an art. To their credit it must be said that radio is miles ahead of the writing that is being done for it. Radio technicians have done astounding things. They have developed their apparatus and their knowledge of transmission to the point where they can do wonders. But there are no wonders to be done. Most of the truck that is on the air is an insult to the excellence of the apparatus that transmits it.

Radio play directors have made exhaustive researches in the realm of noises. They have learned how properly to imitate hundreds of noises in nature. But so far they have been unable to put these noises to any artistic use.

The radio engineers and the studio staffs have done their share. They have set the stage. What they need now is something worth while to put on that stage. And they ought to realize that *they* can't produce it. They must call for outside help. Their position is much like that of an expert violin maker who has put in months of loving craftsmanship in the making of a perfect instrument. This same craftsman doesn't attempt to perform on the fiddle when it is finished. He leaves that to the artist.

So the radio program makers must sooner or later summon the aid of the artist. An artist is attracted to a new medium by four different factors: *1.* The artistic possibilities of the new medium. *2.* The possibilities of reaching an appreciative audience through that medium. *3.* The permanence of the medium. And, *4.* The rewards available in that medium.

That radio has artistic possibilities we are firmly convinced. That radio has a large and sympathetic audience is an obvious fact. That the medium is at present a most ephemeral one happens also to be a fact, but one of no permanent importance. Now, a program is given once and forgotten sixty minutes later. Which is generally what it deserves. But there is no reason why a radio creation of sufficient merit and meaty content could not be given again and again and find a permanent place on the repertoires of stations throughout the world.

As to the rewards available for creative radio program designing, that brings us up against the practical. At present there is no financial inducement for any one to worry his head over the future of radio—unless he be a paid "continuity" writer, in which case he does just enough worrying to earn his salary. Many millions of dollars are spent in this country every year on radio programs. It is our conjecture that of these many millions of dollars less than a tenth of one per cent. goes to paying for the writing of broadcast programs. Much of it is wasted on paying the extravagant bills of opera singers and other overpaid interpretative artists.

If less money were lavished on the individuals who interpret things, and more money spent in getting them something to interpret, matters would be vastly improved.

As a practical suggestion of a method to start the ball rolling, we propose the following:

Let some station or syndicate of stations post a prize of $5000 for the best specially composed program of sixty minutes duration submitted in manuscript by October 1, 1928. The privilege of purchasing other compositions at more ordinary rates could be reserved by the station offering the prize. Certain copyright stipulations would also have to be arranged.

What will this winning composition be like? We will suggest its make-up. It will be a collaberation between a modern composer—a Honneger, say—and a writer or poet. The announcer will introduce it with not more than two or three minutes of explanatory foreword. He will not intrude again. This imagined program will open, say, with a vague rumble of distant noises. They will steadily grow louder and presently organize themselves out of the chaos into recognizable sounds. They will be the noises of nature, perhaps the beating of surf, the noise of a street, or the buzzing of insects. They will constitute the setting. But these noises will be craftily selected, manipulated, minimized, or exaggerated. Some may be amplified to a high degree—as they would sound, for instance, to the keen ears of a wild animal. They will suggest the mood of the entire piece.

Imperceptibly they will melt into music, the music of the symphony orchestra, which will continue to build up the mood. Then the music will grow quieter, a modulation will change its key and its tempo until presently it will merge, without any break, into the human voice. Not your ordinary human voice, but the voice of an artist actor which can convey the slightest nuance of emotion. And the words will not merely be words, but just the right words. They will be as informative as the words in any stage play, but at the same time they will be prose poetry. They will further clarify the situation, or plot, which will of necessity be an elemental and emotional one. The speaker's words may at any time change into song and perhaps back again. Presently the noises will be heard again, or the orchestra, or perhaps a chorus of voices—observers commenting on what transpires. And so on, all these various sound sources will be manipulated and shuttled about until the comedy or the melodrama, the tragedy or fantasy, whatever it is, has come to a close.

In thus briefly setting down our ideas of the possible trend of such a Sound Drama, we have perhaps made the thing seem simply curious and "tricky." Perhaps we have made it seem "highbrow." If it is properly composed and executed it will be none of these. It will be a gripping emotional thing that will completely carry us away. It will not be something vague and disjointed that we will forget immediately it is over, but something rememberable and pleasurable. And it will have accomplished its end, not through visible means, nor verbal description, but through an appeal to that much neglected organ of ours—the ear.

And still the broadcaster laments that he "can appeal to his audience only through sound—nothing else!"

"Our Readers Suggest—"

"OUR Readers Suggest. . ." is a regular feature of Radio Broadcast, *made up of contributions from our readers dealing with their experiences in the use of radio apparatus. Little "kinks," the result of experience, which give improved operation, will be described here. Regular space rates will be paid for contributions accepted, and these should be addressed to "Our Readers Suggest Editor,"* Radio Broadcast, *Garden City, New York.*

—The Editor

Remote Volume Control

THE operation of a receiver by remote control is an interesting possibility, and one that has intrigued many engineering minds. The mechanical and electrical complications of existing systems are such, however, as to preclude their general use. It is, nevertheless, a relatively simple matter to control the volume of a receiver from your easy chair, which, though only partially solving the problem, is really a great convenience. The radio fan is, I think, inherently a lazy individual. Writing from personal experience I may say that there is nothing more annoying than finding it necessary to rise from a comfortable chair or sofa to tone down or bring up volume on a receiver that a few minutes before was apparently correctly adjusted.

Fans indisposed to labor have undoubtedly noted that the volume of a receiver is anything but constant. An original adjustment made when the broadcaster was using the soft pedal, proves entirely off on a fortissimo passage. Also, in congested radio districts, the intensity of signals, I have found, varies considerably with the number of receivers tuned to the same program in the immediate neighborhood. This is not due to an absorption effect upon the field strength, but rather to a parallel wave trap effect. Regardless of the reason, the condition exists and can be made more tolerable by providing a means of volume control from wherever the indolent listener may be reclining.

The writer uses a variable zero to five-thousand ohm resistor connected between the antenna and ground posts of the receiver by means of a long flexible telephone cord. This is employed as an auxiliary volume control to the adjustment provided on the receiver itself. The original volume control is set for a degree of volume quite a bit in excess of comfortable listening, and is toned down by the external control.

I have found that practically any variable resistor, covering a range of from five to at least five-hundred ohms, is satisfactory for the purpose described. It is apparently immaterial whether or not the resistor is inductive.

James Montague,
Newark, New Jersey.

STAFF COMMENT

ELECTRAD, Clarostat, Yaxley and others are manufacturing remote volume controls of the type described by our contributor. Their use in the antenna circuit, where, of course, signal

A NEW CLAROSTAT

It is the remote volume control type. Electrad Yaxley and others have similar controls

intensity is reduced before the signal is impressed on the audio-frequency circuits, precludes the possibility of overloading, with resulting distortion.

Devices of this nature can be made to serve a utilitarian purpose other than Mr. Montague's commendable moral support to laziness. Such a volume control installed near the telephone is a logical arrangement of genuine utility, and will be greatly appreciated by persons who have endeavored to converse over the 'phone in competition with the radio.

Improving Your B Device

SEVERAL articles have appeared in "Our Readers Suggest" department on the improvement of socket power devices. These articles have considered, singly, the stabilizing possibility of the glow tube, the use of additional resistors to obtain desired plate potentials, and the use of C biasing resistors. It is the purpose of this article to describe a simple arrangement which takes care in one unit of these various desirable possibilities.

The starting point in improving the existing B device is in the rectifier tube. In this connection it is necessary first to clarify a misunderstanding which has gained ground of late, namely, that a rectifier tube, when renewed, must be replaced bv one of identically the same type.

With virtually any good Raytheon B socket power outfit heretofore provided with the Raytheon B type rectifier, an increase in voltage output may be obtained by substituting the present Raytheon type BH tube for the old B type. The voltage, providing it was adequate for the requirements of the output tube used before this substitution, now is of sufficient value to take care of the grid biasing requirements of the power tube as well as its plate supply demands.

Other improvements for B devices have taken the form of better voltage regulation at the output end. Reliable potentiometer resistances, together with a voltage regulator tube, will maintain fixed voltages across two or more terminals.

The photographs on page 34 present an adapter which may be connected to many of the better quality B power units so as to incorporate the advantages of a potentiometer resistance network and a regulator tube, while increased voltage output is obtained for use as grid bias by replacing the B type with the BH type Raytheon, as mentioned above. It will be noted from Fig. 2 that the adapter comprises a tapped potentiometer resistance, two bypass condensers, a socket for the R (regulator) tube, and a special current-limiting resistor for use in the third element circuit of the regulator tube. These few parts, along with the necessary binding posts, may be mounted in almost any desirable manner.

Fig. 1 shows a typical B unit circuit, with the original resistors supplying the potential requirements of last year's receivers. Fig. 21 shows a wiring diagram of the additional unit described by the author. Point "A" is connected to point "A" in Fig. 1 and point "B" to point "B" in Fig. 1. The center choke tap runs through the

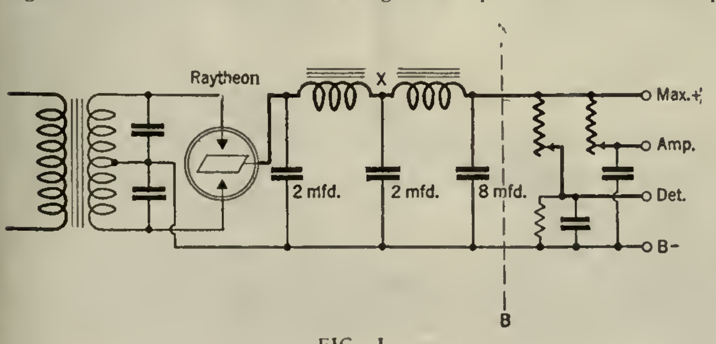


FIG. 1

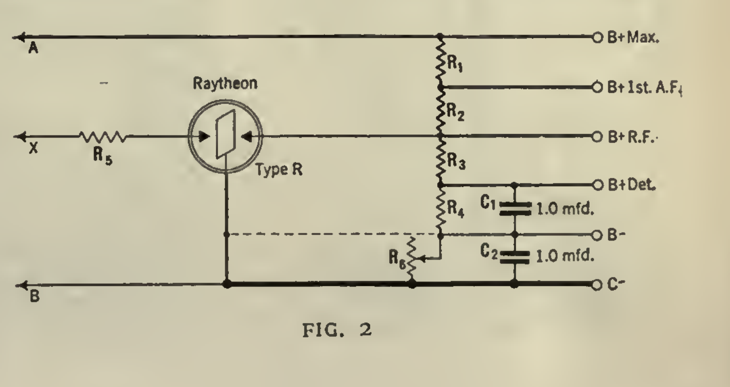


FIG. 2

9000-ohm resistor to the metallic base of the regulator tube from "X" in Fig. 21 to "X" in Fig. 1.

The following table shows the value of the resistors designated in Fig. 2:

R_1 1000 ohms, 5 watts
R_2 2000 ohms, 5 watts
R_3 50000 ohms, 2 watts
R_4 20000 ohms, 2 watts
R_5 9000 ohms, 5 watts
R_6 2000 ohms, (double potentiometer, such as the Amsco "duostat")

The constructor should find no difficulty in following the layout of parts by reference to the photographs.

D. E. Replogle,
Cambridge, Massachusetts.

STAFF COMMENT

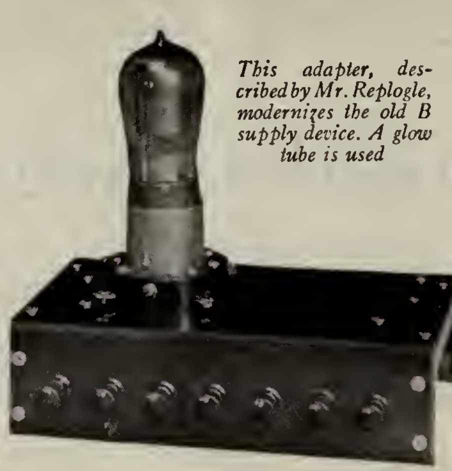
THE arrangement shown in Fig. 2 may be used with practically any socket power device. As was pointed out in previous articles of this nature in "Our Readers Suggest" Department, however, the C bias arrangement should be employed only with a socket power unit capable of delivering a total voltage output under load equalling the sum of the maximum plate and grid voltage required. The grid bias feature may be eliminated by the omission of C_2 and R_6 and by the connection of the bottom of R_4 to the regulator tube and to "B" on the regular B device. This connection is indicated in dotted lines, the heavy line being, of course, left out

Plate Detection

THE advantages of using a C battery for bias in the detector circuit may be retained without the use of an extra battery by a simple change in the wiring of any circuit. In the writer's case a resistance-coupled audio amplifier is used for the first stage. The detector grid condenser and leak are no longer used, and are "shorted" out of the circuit.

Connect the detector rheostat in the A minus filament line and connect the grid return as shown in Fig. 3, which arrangement utilizes the negative bias obtained by the drop across the filament rheostat. A definite value of resistance in the detector plate circuit will be found to work best with each value of C bias. In this case a one-megohm leak was found to be right when ninety volts was used with a 201-A type tube.

This arrangement was found to be practically as sensitive as the usual circuit having a grid leak and condenser, and at the same time had



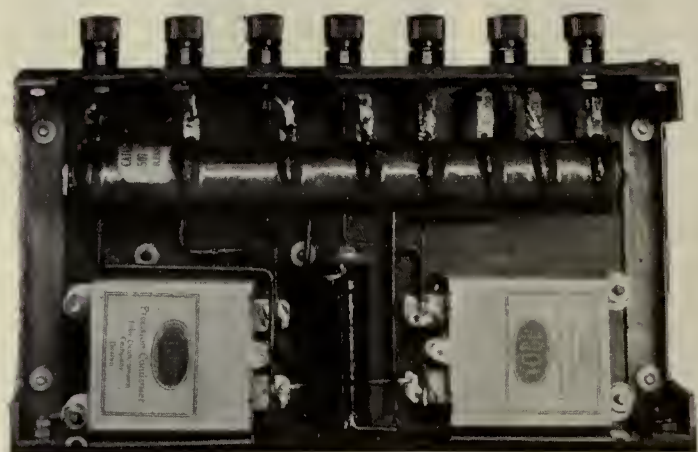
This adapter, described by Mr. Replogle, modernizes the old B supply device. A glow tube is used

the selectivity and tone qualities gained by employing plate detection.

Karl V. Nyquist,
Stromsbing, Nebraska.

STAFF COMMENT

DETECTING on the lower bend of the plate-current grid potential characteristic curve, like most justifiable variations from an average procedure, is characterized both by advantages and disadvantages. The possibility of distortion due to overloading of the detector circuit is reduced in the so-called plate method of



AN UNDER VIEW OF THE DEVICE DESCRIBED BY MR. REPLOGLE

detection. The sensitivity of the detecting circuit is, however, generally lessened. In the case under consideration, the loss in signal strength is probably negligible due to the fact that the relatively low plate potential is secured by increasing the resistance in the plate circuit of the detector tube to approximately ten times the value employed in the grid current detecting system. Increasing the value of the external plate resistor in a resistance-coupled amplifier, while still maintaining the applied plate voltage at an optimum value for detection, increases the input to the amplifier, which in this instance, partially compensates the loss in detecting efficiency.

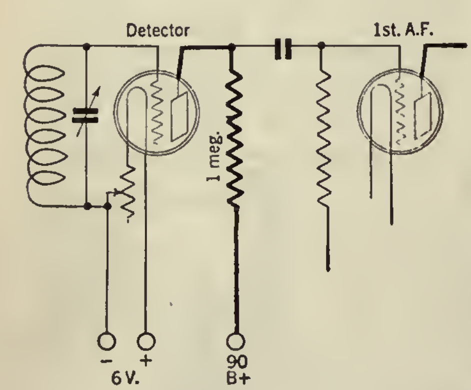


FIG. 3
A useful circuit for plate detection

Adjusting Cone Loud Speakers

FOR THE proper adjustment of a cone loud speaker, it is essential that the pin be exactly centered in the collar at the apex. It often happens that in the rough handling of transportation the movement of the loud speaker is shifted slightly from dead center with the result that there is a strong tension on the pin. This limits the amount of power the loud speaker can handle without distortion. The correct adjustment can be easily made with the aid of such simple apparatus as is generally found in the radio equipped home.

A 110-volt lamp of indiscriminate wattage, a house current plug, and a 1000-ohm resistor are required to make the adjustment. This apparatus is placed in series with 110 volts a. c. and the loud speaker. The set screw on the loud speaker collar is loosened and the circuit shown in Fig. 4 is closed. A 120-cycle hum will be distinctly heard in the loud speaker. The screws holding the frame should be loosened slightly and the actuating mechanism moved from side to side and up and down until the sound is at a minimum. With the set screw loosened the loud speaker will rattle freely at this adjustment. The current is turned off and the set screw is tightened down upon the pin.

Harry Wirth,
New York City.

Selectivity with A. C. Tubes

HAVING had occasion to alter a half dozen or so battery receivers for a. c. operation, with both the R. C. A. and Arcturus types of tube, I have noticed that the selectivity of the battery receiver has been, in every case, noticeably superior to that of the rewired job. In the course of my experiments, however, I found that the selectivity of the a. c. set could be improved until it was quite on a par with the original 201-A job, by increasing the negative bias on the r. f. tubes.

Walter Bennett,
New York City.

STAFF COMMENT

WITH coils designed for tubes having the characteristics of the 201-A type tube, the substitution of alternating-current tubes of a lower input impedance will necessarily result in the loss of selectivity, generally accompanied with an increase in sensitivity. These effects can be compensated, as suggested by Mr. Bennett, by increasing the grid bias applied to the radio-frequency tubes. It will be found that, at the point at which the selectivity is equal to that of the d. c. set, the sensitivity will also have been readjusted to the same degree characterizing the original battery receiver.

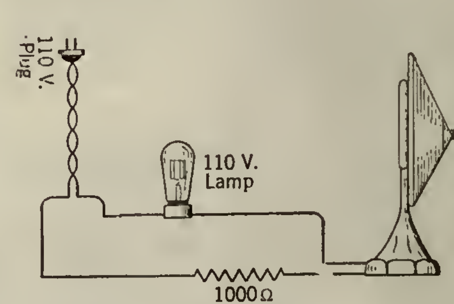


FIG. 4
A simple arrangement for the adjusting of cone loud speakers. Unless properly adjusted, the cone loud speaker will not give its maximum undistorted volume

PRODUCTS of radio manufacturers whether new or old are always interesting to our readers. These pages, which will be a regular feature of Radio Broadcast *from this issue on will explain and illustrate certain products which have been selected for publication because of their special interest to our readers. This information is prepared by the Technical Staff and is in a form which we believe will be most useful. We have, wherever possible, suggested special uses for the device mentioned. It is of course not possible to include all the information about each device which is available. Each description bears a serial number and if you desire additional information direct from the manufacturer concerned, please address a letter to the Service Department,* Radio Broadcast, *Garden City, New York, referring to the serial numbers of the devices which interest you and we shall see that your request is promptly handled.*—The Editor.

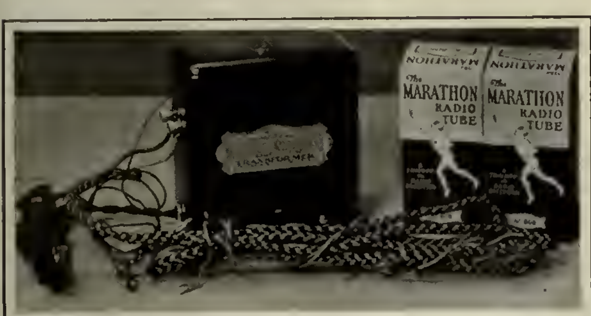
New Apparatus

A Complete A. C. Adapter Unit

X21

Device: Marathon A. C. Harness equipment. Consists of a cable conductor, a transformer, supplying the correct voltage for Marathon tubes, type AC 608, and a volume control. The Marathon a. c. tube is of the heater type and is rated at 6 volts and 1 ampere. Manufactured by the Northern Manufacturing Company. *Price*: $30.00 (5 or 6-tube kit); seven and eight-tube units available.

Application: In order to make the conversion of a d. c. set to a. c. operation a simple matter using Marathon tubes, this company is supplying the accessory apparatus (transformer, cable, and volume control) required. It should be understood that this apparatus is made especially for use with Marathon tubes; the transformer voltage is incorrect for other types of a. c. tubes. The Marathon a. c. tube is equipped with two extra terminals on the side of the tube base and the filament transformer terminals need merely be connected to these convenient terminals using the harness supplied for the purpose in this kit, and the tubes plugged into the regular sockets in the receiver. No adapters are required. This is a distinct advantage when space is limited for these tubes, when installed, will project no higher than the storage battery type tubes used formerly in the set. When 226 and 227 type tubes are used with the necessary adapters the overall height of the tube and adapter is greater than that of a storage battery tube and this fact will, in some a. c. conversion jobs, give some difficulty and necessitate rearrangement of some apparatus.

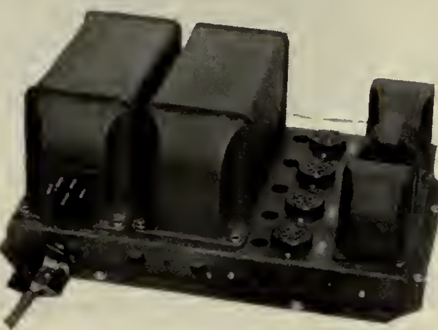


THE MARATHON A. C. KIT

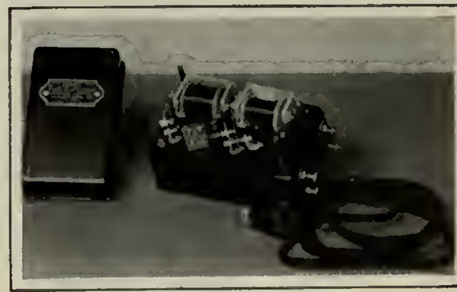
Complete A. C. Push-Pull Amplifier

X22

Device: Samson Power Audio Amplifier, Types PAM-16 and PAM-17 for use with radio receivers or phonograph pick-ups. Both types are exactly the same except that the type PAM-17 is equipped to supply 40 milliamperes at 120 volts to the field winding of a Magnavox, or similar dynamic type loud speaker. The amplifier is a two-stage transformer-coupled unit and consists of an input transformer followed by a type 227 a. c. tube which in turn feeds into the primary of a push-pull transformer. Two 210 type tubes are used in the push-pull stage. The filaments of the 210 type tubes are operated on a. c. and plate power for them is obtained from a rectifier-filter system using a type 281 tube. As indicated in the circuit diagram one of the input leads is shielded. This lead connects the input of the amplifier to the output of the detector in the radio receiver (or output of a phonograph pickup if one is used). Electrically the device has been arranged to conform with the underwriters' specifications, all the wiring being entirely enclosed. The terminals of the audio transformers project down through the base of the transformers into the sub-base, and are therefore unexposed.



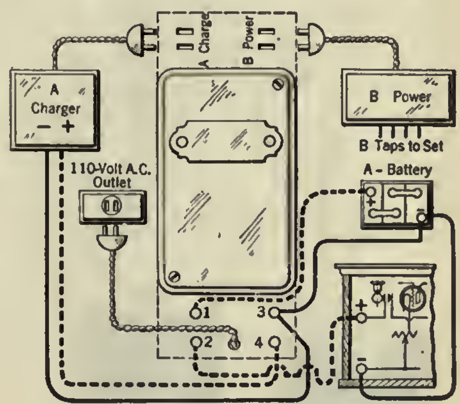
SAMSON PHONOGRAPH OR RADIO AMPLIFIER



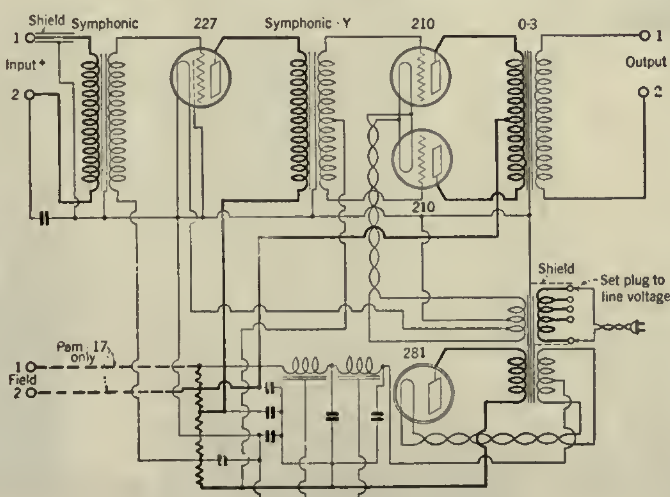
YAXLEY'S POWER CONTROL

Manufactured by the Samson Electric Manufacturing Company. *Price*: $125.00.

Application: This amplifier can be connected to the output of the detector tube in a radio receiver, being used therefore instead of the amplifier in the set, or it may be used in conjunction with a phonograph pick-up to reproduce phonograph records. At a recent R. M. A. meeting, Mr. Cotton of the Samson Company demonstrated the amplifier to two of the staff of Radio Broadcast Laboratory and the reproduction from phonograph records was excellent. There was absolutely no hum audible in the Western Electric 540 AW cone used. The unit is beautifully finished and is very well arranged mechanically and electrically. Complete data, blue prints, etc., are available from the Samson Company.



HOW TO USE THE YAXLEY POWER CONTROL



CIRCUIT OF SAMSON AMPLIFIER

At Last—Automatic Power Control

X23

Device: Yaxley Full Automatic Power Control. For the automatic control of the power units used with a radio receiver. Manufactured by Yaxley Manufacturing Company. *Price:* $7.50.

Application: This device, designed automatically to control a receiver installation operated from a B supply and a trickle-charger storage battery combination, functions (a) to turn on the trickle charger and turn off the B power unit when the set is turned off, (b) turn off the trickle charger and turn on the B power unit when the set is turned on and, (c) cut out the trickle charger when the battery is fully charged. All of

this is accomplished automatically by merely turning the filament switch on the receiver off and on. It is evident from the description above that the functioning of this device differs from that of an ordinary power control device in that a relay in this unit is adjusted to cut out the trickle charger when the battery is fully charged so that there is no possibility of overcharging the battery. The device will function with sets having any number of tubes.

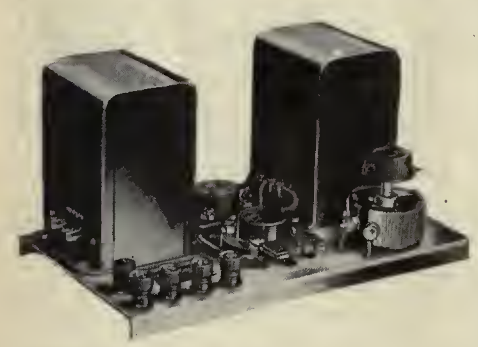
TOBE'S INTERFERENCE FILTER

Heavy-Duty Interference Filter

X24

Device: Interference Filter No. 2. Consists of a combination of filter choke coils and filter condensers, all assembled in a single case. Manufactured by the TOBE DEUTSCHMANN COMPANY. *Price:* $15.00.

Application: This filter is designed for use in conjunction with small motors and other devices which are acting as sources of radio interference. This filter may be used with motors rated up to 5 horsepower; for smaller motors, interference filter No. 1 may be used. The filter is connected. in series with the power line, close to the piece of apparatus producing the interference. The Tobe Deutschmann Company will supply any special filter that may be necessary for unusual cases.



GENERAL RADIO PUSH-PULL AMPLIFIER

A. C. or D. C. Push-Pull Amplifier Complete

X25

Device: Push-pull Power Amplifier Type 441. The filament wiring is arranged so that the filaments may be lighted from either a. c. or d. c. The input impedance of this amplifier is 30 henries and the turns ratio of the input transformer to the entire secondary is 4.5. The output transformer has a step-down ratio in voltage of 3.5 to 1, to adapt the tube to the loud speaker impedance. This gives a good ratio for 112 and 226 type tubes. If 171 type tubes are used it will be better to connect the loud speaker between one plate terminal and the B Plus terminal of the output transformer. Completely assembled. Manufactured by the GENERAL RADIO COMPANY. *Price*: $20.00.

Application: For use as a last stage amplifier in conjunction with any standard receiver. Any type of tube may be used in the amplifier, the choice depending on the amount of voltage available for driving the unit and upon the amount of power output that is desired. This push-pull amplifier might be used with 112 or 120 type tubes where moderate amounts of power are desired and with 171 type tubes when greater power is required. An amplifier of this type, in use in RADIO BROADCAST Laboratory for some time, has been giving very satisfactory results.

Volume Control Unit

X26

Device: Table Type Clarostat. Consists of a Clarostat variable resistance, mounted in a small metal case, and supplied with extension cords so that it may easily be connected between the receiver and the loud speaker. Manufactured by the AMERICAN MECHANICAL LABORATORIES. *Price:* $2.50.

Application: A convenient accessory, readily attached to any radio receiver, to control the volume of signal from the loud speaker. And as the advertisements say, it will control the volume from a "whisper to a roar."

Although the device is primarily intended for use as a volume control in the loud speaker circuit, there is no reason why it can't be put to any of the other uses for which a Clarostat is suited, such as controlling oscillations in the r. f. amplifier, by connecting it in series with the B+ lead to the radio frequency tubes. This device might also be used as a volume control when connected in parallel across the antenna and ground of a receiving set installation.

Filament Transformer for A. C. Tubes

X27

Device: A. C. Filament Lighting Transformer Model T-1. Supplies following voltages:

1½ volts—Capacity for seven type 226 tubes
2½ volts—Capacity for four type 227 tubes
5 volts—Capacity for two type 112 or 171 tubes

The transformer is arranged with a flexible lead to be plugged into one of three possible jacks which permit the transformer to be operated on line voltage from 80 to 125 volts. Condensers and center-topped resistors necessary for a. c. tubes contained in transformer case. Manufacturer: HAROLD J. POWER, INC. *Price:* $10.00.

Application: May be used to supply filament current to a. c. tubes in a radio receiver. The flexible lead by which different line voltages can be compensated is an excellent feature for a. c. tubes, especially the 227 heater type, which have a very short life if supplied with excessive filament voltage. Wiring diagrams of various standard receivers revised for a. c. operation may be obtained by writing the manufacturers of this device.

Drum Dial and Adjustable Gang Condenser

X28

Device: Gang Condenser and Drum Dial. The apparatus contains the following features:

1. All of the condensers are mounted on a single shaft and the condensers may be adjusted to any desired spacing between them by merely loosening two set screws and sliding the condenser along the shaft to the desired position.

PRECISE DIAL AND GANG CONDENSER

2. Each condenser is equipped with an adjustment for slightly altering its capacity, so that accurate tuning of each circuit in a single-control set can be accomplished. The photograph illustrates such an adjustment being made, a procedure which is only necessary when the set is placed in operation for the first time.

3. The spacing between the condenser plates is quite large so that the capacity of the condenser will not be affected to any considerable extent by variation in the thickness of the plates.

4. Any number of condensers may be used in the assembly. Each condenser has a capacity of 0.00035 mfd. The drum dial is equipped for a dial light and reads from o. to 100, the scale being also approximately calibrated in wavelengths. Manufactured by the PRECISE MANUFACTURING COMPANY. *Price:* (drum dial assembly, $5.00; variable condensers, 0.00035 mfd., $6.00). *Application:* May be used in constructing a single-control receiver.

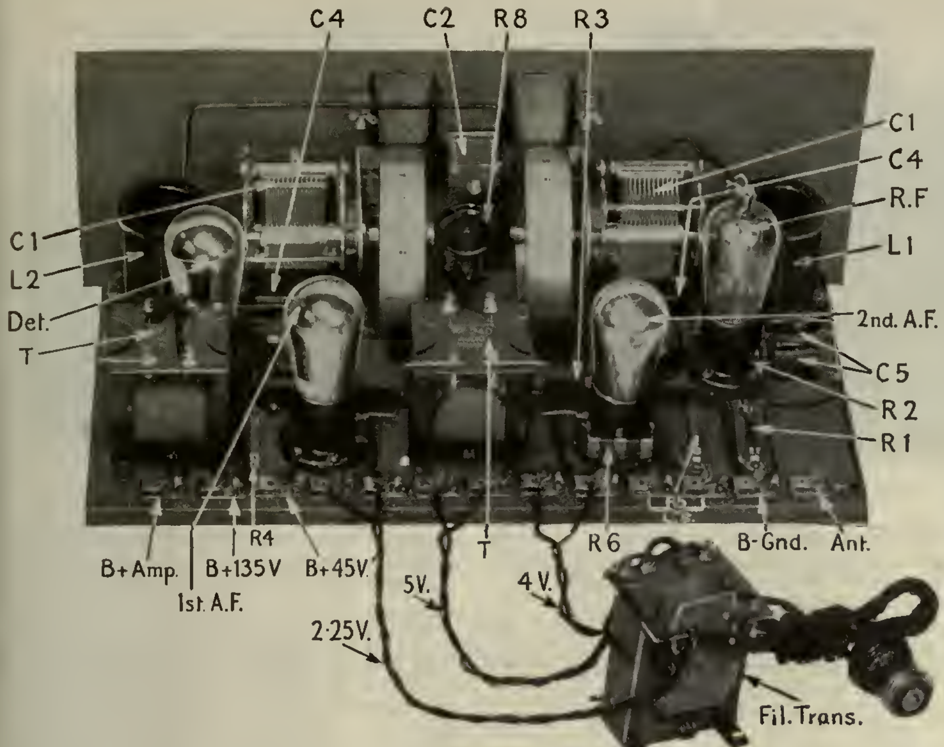
Loud Speaker

X29

Device: Rola Table Type Loud Speaker, Model 20. Finished in hand-rubbed walnut. 11½ inches high, 11¾ inches wide and 6¾ inches deep. Frequency range, according to the manufacturers, is approximately 70 to 5000 cycles. The loud speaker is equipped with a filter to suppress the higher frequencies. The armature of the unit is laminated, evidently to obtain higher efficiency. Manufactured by the ROLA COMPANY. *Price:* $35.00.

Application: This loud speaker may, of course, be used with any standard radio receiver. The manufacturers recommend the speaker especially for use with a. c. sets, because of its "tendency to suppress and minimize the residual hum characteristic of most a. c. sets."

NEW ROLA CONE



An A.C. Screen-Grid Receiver

ALTERNATING-current operation of screen-grid tubes has been in the minds of many experimenters, judging from the amount of correspondence received by RADIO BROADCAST, and by the number of visitors to the Laboratory who have broached this subject. The receiver described here is the first that has come into the Laboratory which shows how this may be accomplished. After all the speculation regarding the possibilities of a. c. operation of this new tube, the trick of how to do it seems to be no trick at all; all one needs is a source of a. c. voltage of the proper value—3.3. volts.

The receiver, originally designed for d. c. operation, was described in the March RADIO BROADCAST. It covers, with plug-in coils, all frequencies between 100 and 10,000 kc., and consists simply of a stage of radio-frequency amplification using the screen grid-tube, a regenerative detector, and two stages of audio-frequency amplification, transformer-coupled. All tubes in the present adaptation of this receiver operate from a. c., the voltage for the screen-grid tube being obtained by connecting in series the 1.5- and the 2.5-volt windings of a standard filament transformer, and then dropping the resultant 4 volts to the proper value, 3.3, by means of a 4-ohm resistance. The output tube is a 112-A and the detector and first audio amplifier are heater type C-327 or UY-227 tubes. In the proper places in the circuit are bias resistances so that not even C batteries are necessary for the receiver's operation.

In the Laboratory the use of a. c. on the screen-grid tube's filament contributed no a. c. hum to the output from the loud speaker. When listening with a pair of phones across the output, the hum which is audible is no greater than that of any two-stage audio amplifier and detector operating entirely from a. c.

The difference in circuit between the original d. c. receiver and the present one can be determined by reference to the accompanying diagrams, Figs. 1 and 2. Aside from the a. c. wiring, and the addition of C bias resistors in their proper places, another change is that the grid leak is placed across the grid condenser instead of from grid to plus filament. This is because the heater type of tube has no filament proper, and all grid and plate returns are connected to the fifth or cathode post of the tube.

Reference to the diagram of the a. c. model, Fig. 2, shows the following resistances which are not in the d. c. set: R_1, 1500 ohms, to furnish C bias for the screen-grid tube; R_2, 64 ohms, center-tapped, across the filament of this tube, the center point connecting to ground through the bias resistance; R_1; R_3, 4 ohms, to drop the output voltage of the transformer to 3.3 volts for the filament of the screen-grid tube; R_4, 1500 ohms, in the grid return lead of the first audio tube to supply C bias to this tube; R_5, 2000 ohms, to furnish C bias to the last tube; and R_6, another 64-ohm center-tapped resistance for the last tube, the center connecting through the bias resistance to ground. There are also two 0.1-mfd. condensers across the center-tapped and bias resistances on the screen-grid tube to act as radio-frequency bypasses, and there is a 500,000-ohm potentiometer across the secondary of the first audio transformer to act as a volume control. A 1-mfd. condenser across the C bias resistor of the final tube is optional. Its inclusion will provide better bass note reproduction. Naturally, UY sockets must be used in place of standard sockets, for the two heater type tubes now used in the detector and first audio stages. Otherwise the present receiver is exactly like the one described in March. It covers the same frequency ranges,

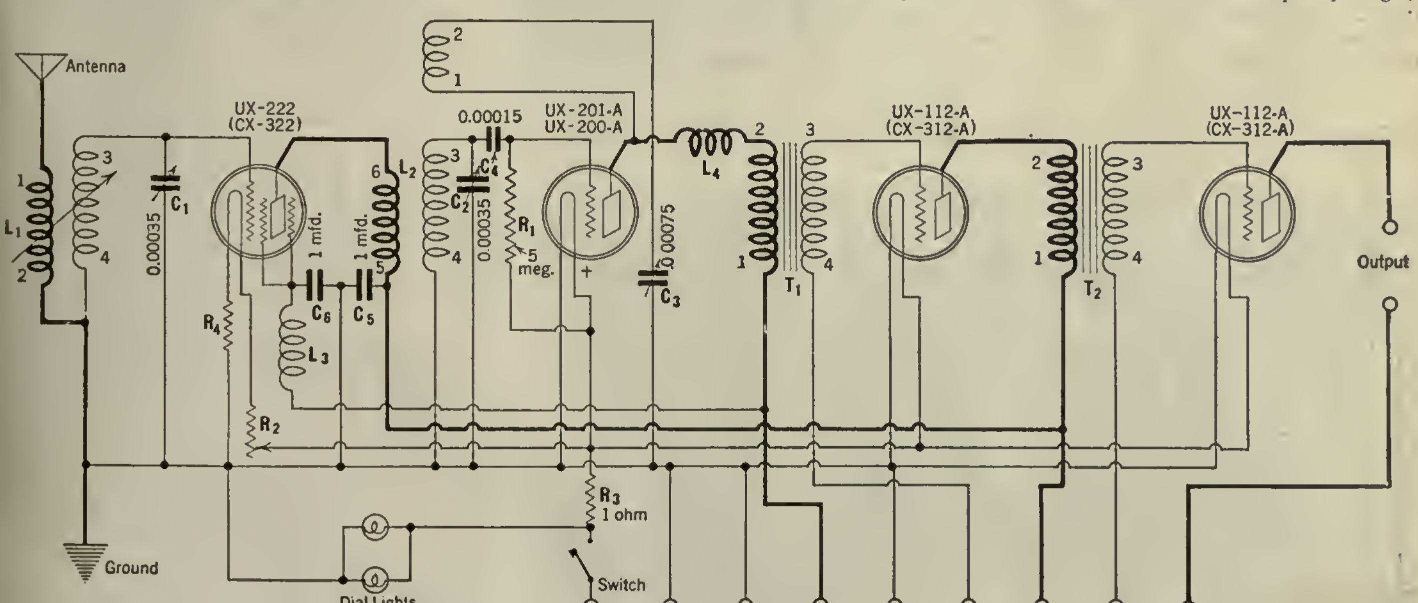


FIG. 1
A schematic diagram of the four-tube receiver as originally designed for d.c. operation

uses the same parts, is laid out on the panel and baseboard similarly, and its operation differs not at all.

As stated before, to get 3.3 volts for the first tube's filament it is necessary to connect in series the 2.5-volt and the 1.5-volt windings of the standard filament transformer. If these windings are not connected together properly, the screen-grid tube will not light. No harm can be done, however, by such a connection, and, therefore, the builder can easily determine which connection is proper.

The voltage on the filament of the screen-grid tube is not critical as to hum; the variation in voltages occurring in practice, due to line fluctuations etc., are not great enough to cause hum.

THE CONTROLS ARE GROUPED CLOSELY TOGETHER ON THE FRONT PANEL

While the arrangement used for the operation of the 222 tube in the four-tube set has not been tried with two or three r. f. stages yet, there appears no reason why it should not function satisfactorily, and the application of a. c. operation to two- and three-stage screen-grid r. f. amplifiers should prove a most fertile field of experiment.

The parts used for constructing the four-tube a. c. screen-grid receiver are listed below. While the parts specified are recommended, the experimenter may substitute other makes of parts electrically equivalent with safety:

L_1—S-M 111A Antenna Coil	$ 2.50
L_2—S-M 114SG R. F. Coil	2.50
Two S-M 515 Universal Interchangeable Coil Sockets	2.00
L_3—Two S-M 275 R. F. Chokes	1.80
T—Two S-M 240 Audio Transformers	12.00
C_1—Two S-M 320 0.00035-Mfd. Variable Condensers	6.50
C_2—S-M 342 0.000075-Mfd. Midget Condenser	1.50
C_3—Sangamo 0.00015-Mfd. Condenser with Leak Clips	.50
C_4—Two Fast 1-Mfd. Condensers	1.80
C_5—Two Sprague 0.1-Mfd. Bypass Condensers	1.70
R_1, R_4—Yaxley 1500-Ohm Grid Resistors	1.00
R_2, R_6—Two Frost FT64 Balancing Resistors	1.00
R_3—Carter 4-Ohm Resistor	.25
R_5—Yaxley 2000-Ohm Grid Resistor	.50
R_7—Durham 5-Megohm Grid Leak	.25
R_8—Carter 500,000-Ohm Volume Control Potentiometer	2.00
Thirteen Fahnestock Connection Clips	.65
Two S-M 511 Tube Sockets	1.00
Two S-M 512 Tube Sockets	1.50
Two S-M 805 Vernier Drum Dials	6.00
7x17x½" Wood Baseboard, with Hardware	1.50
1 Van Doorn 7x18" Decorated Metal Panel	3.00

AND THE FOLLOWING ACCESSORIES

UX-112-A (CX-312-A) Power Tube
UX-222 (CX-322) Screened Grid Tube
Two UY-227 (C-327) Heater Tubes
Cone Loud Speaker
Filament-Lighting Transformer with 1½-, 2½- and 5-Volt Secondaries, such as the S-M 247 Illustrated.
Three 45-Volt Heavy-Duty B Batteries, or Any Standard Socket Power Unit Capable of Accurate Voltage Adjustment.

The coils listed above are suitable to cover the broadcasting frequencies. Other coils from the same manufacturer make the receiver truly universal insofar as wavelength range is concerned.

To hook this set up, it is simply necessary to connect the B batteries (or the socket power supply), loud speaker, antenna and ground, to the clips marked in the illustration, and to insert the tubes. The filament transformer must be connected to its appropriate clips by means of carefully twisted wires. Preferably, it should be situated a foot or so from the audio transformers in the receiver.

The receiver operates exactly as any other set of its type, the two station selector dials serving to tune-in the different stations in the broadcast band of 200 to 550 meters, the midget regeneration condenser controlling sensitivity (regenerative amplification) and the volume knob controlling loud speaker volume. No "On-Off" switch has been provided in the set for it is assumed that the socket-power unit or filament transformer used will be provided with a switch either in the instrument itself, or in the connecting cord, or if in neither, the set may easily be turned on or off at the lamp socket to which the power unit supply cord is attached. Using the standard 111-A and 114-SG coils the set tunes from 200 to 550 meters, while by dropping the r. f. stage and connecting the antenna to point 3 of the detector coil socket through a small 0.000025-mfd. midget condenser the set will cover the shorter wavelength ranges from 30 to 75 meters with 114-C coil, or 70 to 210 meters with a 114-B coil. Waves above 550 meters may be received with a 111-D and 114-D coils (500 to 1500 meters) or a 111-E and 114-E coil (1400 to 3000 meters). Although there are no American broadcasting stations operating above 550 meters there is great sport for those who know the code on these lower frequency bands. Ships at sea, compass stations, air-mail stations, time signals, and navy vessels—all have wavelengths covered by this receiver. It will be necessary to shunt the regeneration condenser with a fixed capacity of 0.0001-mfd. to get good oscillation control when the D and E range coils are used.

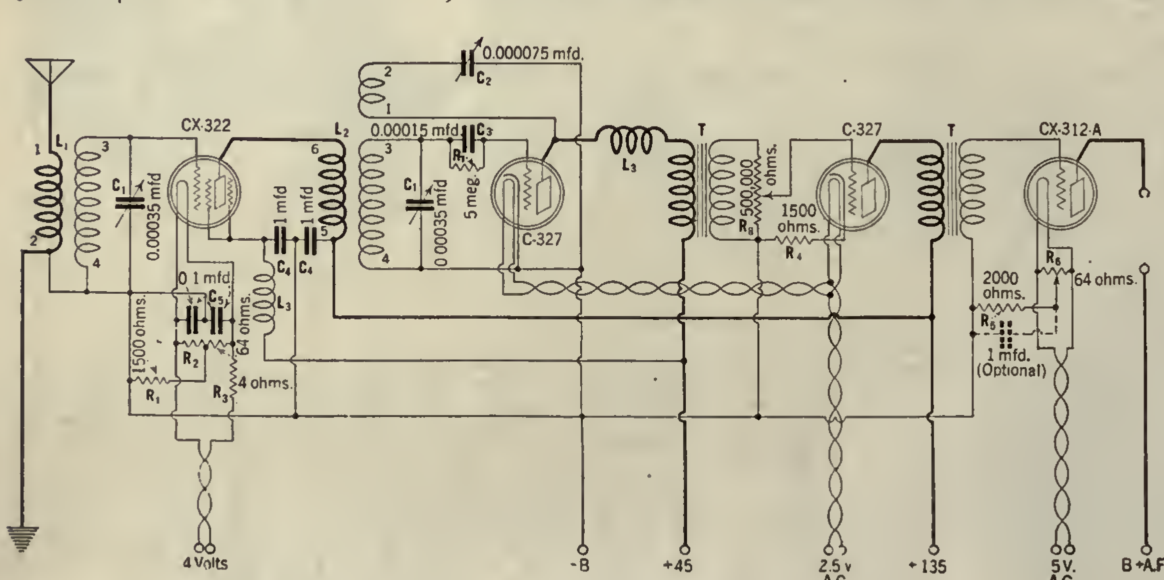


FIG. 2
Circuit diagram of the a.c. screen grid receiver

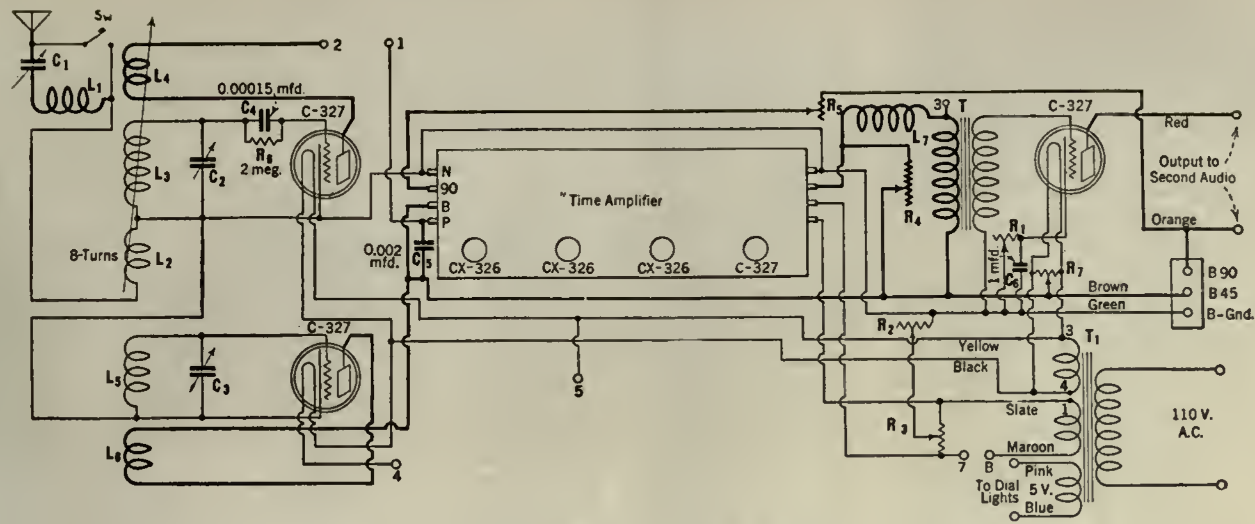


FIG. 1

Switching provides for the use of this circuit either as a super-heterodyne or as a single-circuit receiver

A Flexible A.C. Super-Heterodyne

By Dana Adams

THE receiver described in this article has several unique points of interest which distinguish it from the commonplace. In the first case, it is a.c. operated, a feature which is becoming more and more popular. The most interesting feature of the receiver, however, is the fact that, by the mere flip of a switch, the degree of selectivity and sensitivity of the system may be augmented or decreased, depending upon the requirements of the operator and his geographical location with respect to the station he wishes to hear. The circuit, in its most sensitive form, is a super-heterodyne employing a three-stage intermediate-frequency amplifier. The switching, which controls the selectivity and sensitivity, provides for three circuit arrangements as follows:

1st Position: The receiver is converted into a single-circuit receiver with one tuning control and one volume control, the output of the detector tube inputting directly to the audio amplifier.

2nd Position: Same as 1st Position with the exception that a series condenser in the antenna circuit is switched in by means of a Yaxley No. 10 antenna switch, thus adding a further tuning control, but at the same time improving sensitivity.

3rd Position: The complete super-heterodyne receiver is thrown into operation, a third main tuning control being added. The antenna tuning condenser need not necessarily be switched into circuit in this case.

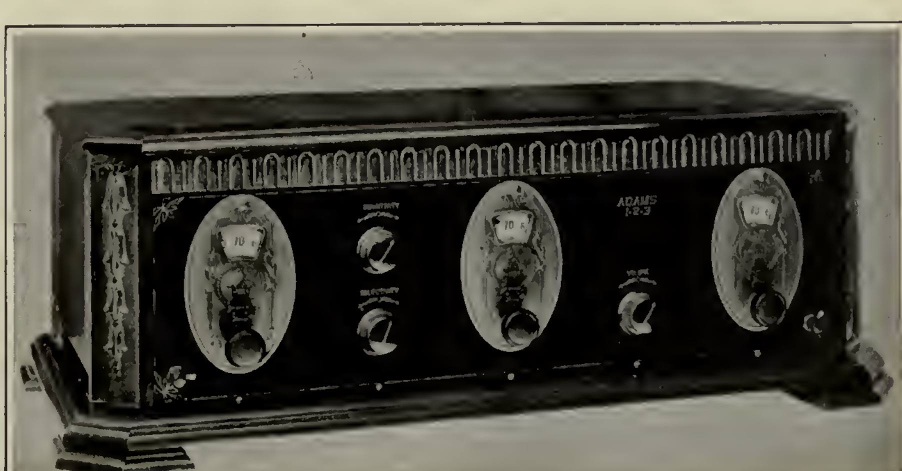
The switch used for switching from single-circuit receiver to super-heterodyne receiver is a Yaxley No. 63 triple-pole switch. In Fig. 1 (the complete circuit diagram up to the output of a single-stage audio amplifier), various connections to this switch are indicated by number but are not grouped. The numbers for the switch terminals are determined by counting from right to left from a rear view of the switch.

Fig. 1 shows a coil and the condenser in series with the antenna. Variation of this condenser tunes the antenna to any desired frequency in the same manner that the grid circuit of a tube is tuned, with a consequent increase in signal strength. At the same time, the strength of signals flowing in the antenna circuit at other than the resonant frequency is reduced, following the law of all series-tuned circuits. Laboratory measurements show this gain at the resonant frequency to be equal to that of one radio-frequency stage. Coupling to the detector circuit is obtained through a small variable coil, L_2, which is a part of the Samson No. 31 coupler (which comprises L_2, L_3, and L_4). This coupling coil, particularly when the antenna tuning is used, is generally set very near the minimum coupling point, with a consequent increase in selectivity.

Having made the antenna circuit and the coupling method as efficient as possible we turn next to the first detector. This tube is regenerative with the sensitive grid leak and condenser method of detection and at this point the circuit departs from the ordinary. The Yaxley No. 63 triple-pole switch is used here to cut out the oscillator and intermediate stages of the receiver, at the same time transferring the first detector plate lead from the intermediate amplifier input to that of the audio amplifier. The result is a highly efficient regenerative receiver with an audio amplifier. The middle dial may be used alone in tuning-in the local programs with the antenna coupling acting as a volume control. If additional efficiency is required, a flip of the antenna switch makes the antenna tuning feature immediately available.

A change of position of the three-pole switch returns the detector plate to its normal connection in the super-heterodyne circuit, at the same time lighting the oscillator and intermediate-amplifier tubes, which gives us a two- or three-dial super-heterodyne receiver. Instead of the ordinary coupling coil method of introducing the heterodyne frequency to the detector grid circuit this is done by placing the oscillator coil itself in inductive relation to the detector coil. This eliminates the losses of signal strength frequently caused by a tightly coupled coil which is, in most cases, at ground potential. The oscillator circuit is thus made entirely independent of the receiver except for its power supply. The oscillator circuit is the familiar modified Hartley circuit, grounded rotor plates preventing any hand-capacity while tuning.

The beat note set up by the oscillator and first



A FRONT VIEW OF THE COMPLETE RECEIVER

detector is impressed on the first intermediate-frequency amplifier tube grid. The reader will no doubt recognize the intermediate amplifier as the well-known Silver-Marshall "Jeweller's Time-Signal Amplifier" unit. The high amplification, the sharp cut off of its accurately tuned air-core transformers, and the consistently excellent results obtained with a considerable number of these units, are the reasons for its selection for this receiver.

After the second detector, the audio component of the signal is amplified by one stage of audio amplification. A choke coil together with the bypass condenser included in the amplifier, combine in bypassing the radio-frequency component of the signal to ground, thereby keeping it out of the audio amplifier. The output of this stage is fed to the second audio stage, which has been omitted in the circuit diagram.

To combine the various ideas described above in a receiver employing battery-operated tubes is an easy matter. Fig. 2 shows such an arrangement. True electric operation, however, is convenient and obtained in simplest, cheapest, and least troublesome form with the tubes lighted from an alternating-current source of supply. Tube life when a.c. tubes are used is an important consideration. The writer's experience indicates that excessive filament voltage is the cause of complaints of short life of the a. c. tubes. An almost total lack of measuring instruments is responsible for this condition which time and an increase in knowledge will undoubtedly correct. As all tubes in this receiver are worked at a point well under the rated voltage, uniform and highly satisfactory results are to be expected, the voltage adjustments being extremely easy to make.

GENERAL CONSIDERATIONS

THE omission of a number of details from the review of the receiver, while enabling the reader to obtain a clearer idea of the main features, has no doubt set up a number of questions. The numbers for the switch terminals are determined by counting from right to left from a rear view, as explained previously. The first detector and oscillator circuits may be easily traced with this information at hand. These tubes in these two circuits are of the cathode type in order that the beat note, tremendously amplified in the intermediate stages, will be absolutely free from hum. The CX-326 (UX-226) type tube is used in the three intermediate stages, the 20-ohm potentiometer, R_3, across the filament circuit, providing a mid-tap for the grid returns. The 1000-ohm potentiometer, R_2, biases the grids of these tubes to prevent oscillation and hum, the usual method of running the grids positive being impossible where alternating current is employed. The method of securing the bias voltage will be recognized as that used in biasing the last audio stage in the modern power amplifier. A 50,000-ohm variable resistor, R_4, is shunted across the primary of the audio transformer in order to provide an additional means of reducing the volume when the super-heterodyne is employed. The remaining resistor, the 3000-ohm potentiometer, R_1, provides a common bias voltage for the second detector and first audio stages.

The adapter which is necessary in order that the cathode type tube may be employed in the standard socket in the "Time-Signal Amplifier" is omitted from the diagram for the sake of simplicity. It is referred to in the list of parts. A detailed account of this device will be found later, in the wiring instructions. The various colored leads, ten in number, noted in the diagram, are provided in a single Jones ten-wire cable. This enables the user to disconnect the power from the receiver in a second or so. A Silver-Marshall filament transformer is used to supply the two filament voltages for the a.c. tubes and the voltage for the dial lights. Three of the cable wires provide B voltage to the receiver while a fourth connects the plate of the first audio tube to the primary of the second transformer.

ASSEMBLY

WITH a grasp of the main facts and an idea of the principles employed, the construction of this receiver becomes an extremely simple matter. The first step is that of assembly. All of the apparatus, with the exception of the "Time Amplifier," is put in the positions noted in Fig. 3. The pointers listed below have been gathered from the experiences of a number of builders, and if followed carefully, will insure perfect results.

After mounting the panels and dials the first point to be noted in the assembly is the method of mounting the condensers. The slotted bars provided with the dials are removed and a one-inch machine screw is slipped into the slot in the dial frame. The three collars or bushings furnished with each dial are slipped over the screws. The condensers are then held in the position shown in the photograph and the screws are threaded into the holes provided in the condenser frames. An extremely solid mounting is the result. The tube sockets, audio transformer, switches, bypass condenser, choke-coil, the 50,000-ohm resistor on the panel, and the antenna coil require no special description. The remaining resistors are mounted on the resistor strip which is raised two inches above the baseboard by brackets, in the following order: In No. 1 position place the 3000-ohm potentiometer; No. 2, the 1000-ohm potentiometer; No. 3, the 20-ohm potentiometer; No. 4, the 50,000-ohm resistor.

The double rotor coupler (consisting of L_2, L_3, L_4) used in the first detector circuit to secure variable antenna coupling and regeneration requires altering before mounting. All but eight turns are removed from the antenna coupling rotor, L_2, which is controlled by the lower of the two knobs. The oscillator coil also requires alteration before mounting. Eight turns are removed from the outside end of the large or grid winding of the coil, L_5. This is done so that the detector and oscillator control settings will match although tuned 112 kc. apart. The wire removed from this coil should be added to the plate coil, L_6, at the bottom, insuring sufficient feedback to cause oscillation. This coil is then mounted three eighths of an inch from the coupler, as shown in the photograph, to insure proper coupling.

The wiring of the first detector, audio stage, and oscillator circuits is the next step. A twisted pair from the pink and blue terminals of the cable to each pair of dial light terminals eliminates these from further calculation. From the yellow and black terminals another twisted pair is connected to the contacts of the mid-tap resistor mounted on the filament posts of the audio tube socket. From this point the pair is continued to the detector socket and from there one wire goes to the oscillator tube socket while the other connects to Contact No. 5 on the triple-pole switch. A wire from No. 4 contact on the switch to the remaining filament post completes the wiring of the heater circuits. The remaining wiring to these three tubes may be easily traced from the diagram.

All filament, cathode, and B battery wiring should be formed along the main cable, as shown in the photograph, wherever possible. The leads from the plate of the detector to the switch, from the antenna coil to the coupling coil, and other leads at a high potential from a radio-frequency standpoint. should be formed in a secondary cable close to the panel. Avoid right-angle bends on grid and plate connections; the shorter they are, the better. In wiring the oscillator circuit be sure that the grid and plate connect to the outside ends of their respective coils, or the tube will not oscillate. Pin-jacks may be mounted at the ends of the resistor strip so that a phonograph pick-up or one of the "home-broadcasting" microphones may be employed. One pin-jack should be connected to B minus and the other to the plate terminal of the audio transformer.

The drilling instructions for the resistor strip are shown in Fig. 3. Only two of the three connections on the 1000- and 3000-ohm potentiometers are employed as their function is that of a variable resistor rather than a bridge resistance in this circuit.

The "Time-Signal Amplifier" should be put in position next. The filament wiring should be twisted together and the remaining leads running the length of the receiver should be formed into the main cable. The B minus, plus 45 volt, and plus 90 volt connections should be picked up at the nearest point in the wiring of the other tubes and connected to the proper posts on the amplifier.

The adapter for the second detector tube, referred to previously, is provided with a pair

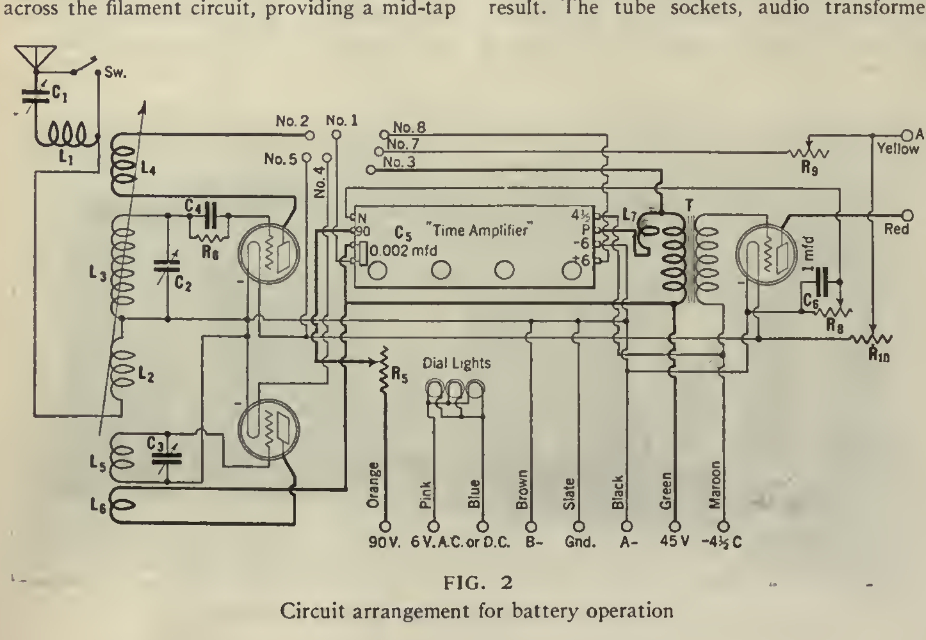


FIG. 2
Circuit arrangement for battery operation

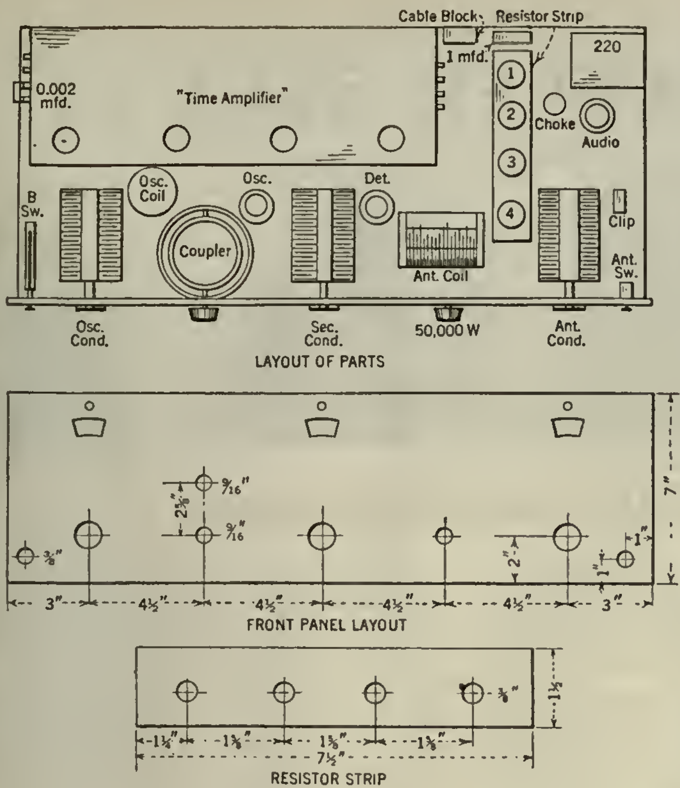


FIG. 3

of filament leads, the pins that normally would supply filament power being dummies. These leads are twisted together and connected to the filament terminals of the oscillator tube socket, the detector then turning on or off with the rest of the intermediate tubes. The grid and plate make the normal connections to the circuit through the adapter pins while the cathode is brought to the pin normally used for negative filament. The wire connecting to the corresponding post on the socket inside the can should be unsoldered and a new wire run out of the shield from this post and connected to the cathode post of the audio amplifier tube socket. The removal of this connection, which is merely a connection to the shield, does not disturb the circuit in any way. The bypass shown across the B and P terminals of the amplifier is most important, as well as the radio-frequency choke in the output lead of this amplifier.

The receiver is now ready for test. To do this properly the power unit that is to be used must be at hand. A few suggestions anent this unit will undoubtedly assist those who are not familiar with this adjunct to quality reception. The combination of a full-wave rectifier, a good filter circuit, and a voltage regulator tube provide the best possible B voltage supply. As the unit is also used to secure C bias, its freedom from ripple is important. Naturally a push-pull CX-310 (UX-210) stage represents the last word for a tremendous amount of undistorted output although a CX-371 A (UX-171) stage will be found sufficient in the average home.

The first step in testing is to throw the switch to the single-circuit receiver position. A minute should elapse before the receiver starts functioning. The 3000-ohm resistor should be set at the halfway position. Failure to operate may be readily traced in this simple two-tube set. Hum audible over a foot from the loud speaker indicates either oscillation, in which case the tickler should be adjusted, or an open circuit. A check of the B voltage at the plate and a test for open grid circuits is sure to locate the trouble. The panel resistor should be turned to the left to obtain greatest volume. After tuning up and down the dial a few times the antenna tuning should be tested by opening the switch. Its effect will be noticed more readily on the weaker stations. The dial setting may be matched within a few divisions of the detector dial by putting a few turns of wire in series with the antenna. This will be necessary only where a short antenna is employed. Up to 150 feet may be used without fear of broad tuning, assuring a stronger signal from distant stations.

The oscillator is tested by tuning-in a station in the middle or lower portion of the wave band and temporarily short-circuiting contacts Nos. 4 and 5 of the switch. After the tube has warmed up the dial should be rotated. A loud heterodyne squeal on the incoming signal indicates the proper functioning of the oscillator. A check up on the connection and the continuity of the grid and plate circuits will readily correct any trouble.

The third step in the testing is that of the intermediate amplifier. The 1000-ohm resistor should be set at a quarter turn from the zero bias point, the 15-ohm potentiometer at the mid-point, and the B resistor slightly below the full-voltage position. A turn of the switch and a few moments wait should see the super-heterodyne in operation. A rapid succession of "birdies" when the oscillator is tuned indicates oscillation in the intermediate stages. This is the only trouble that will be encountered if the wiring has been done in the correct manner. It is readily corrected by reducing the filament voltage. An 0.5-ohm rheostat, which should be located at the filament transformer end of the cable, is the remedy. A slight readjustment of the bias and B-voltage resistor will also be of assistance. It should be borne in mind that the amplifier should be adjusted so that maximum amplification is obtained at all times. The input is controlled by the antenna coupling while the resistor across the transformer primary may be used as an auxiliary means of reducing the tremendous volume that may be obtained, to a reasonable level. While the rheostat takes care of the voltage applied to the CX-326 (UX-226) tubes in excellent fashion, care should be taken that the cathode tubes are not run at an excessive voltage.

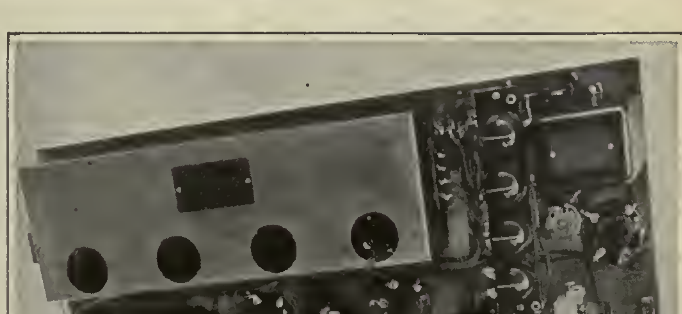
If the receiver is to be operated from an A battery and is to derive its plate voltage from either batteries or power-supply unit, various changes must be made. Three S-M No. 511 sockets will be required in place of the three No. 512 ones indicated in the list of parts. Two Carter IR-6 6-ohm rheostats, R_9 and R_{10}, are also necessary. A Carter M-400-S potentiometer-filament control switch, R_8, is also wired in the circuit. The list of parts for the a.c. receiver:

LIST OF PARTS

C_1, C_2, C_3—Samson No. 65 0.0005-Mfd. Condensers	$22.50
L_1—Samson No. 71 Antenna Coil	2.75
L_2, L_3, L_4—Samson No. 31 Coupler	7.50
L_5, L_6—Samson No. 41 Oscillator Coil	2.85
Three Marco No. 421 Illuminated Controls	10.50
S-M No. 440 Time Amplifier (Includes Three Intermediate Stages and 2nd Detector)	35.00
T—S-M No. 220 Audio Transformer	8.00
L_7—S-M No. 276 Choke Coil	1.00
Three S-M No. 512 Tube Sockets	2.25
Sw—Yaxley No. 10 Antenna Switch	.50
One Yaxley No. 63 Triple-Pole Switch	1.60
R_1—Carter MW-3000 3000-Ohm Potentiometer	1.25
R_2—Carter MW-1000 1000-Ohm Potentiometer	1.25
R_3—Carter MP-20 20-Ohm Potentiometer	.75
R_4, R_5—Carter Type L 50,000-Ohm "Hi-Ohm"	4.00
Carter Cathode Tube Adapter	1.10
R_6—Durham 2-Megohm Leak	.50
R_7—Frost FT-64 Mid-Tap Resistor	.50
C_4—Carter 0.00015-Mfd. Grid Condenser, with Clips	.40
C_5—Carter 0.002-Mfd. Condenser	.50
C_6—Carter No. 210 1-Mfd. Bypass Condenser	1.25
Jones No. BM 410 Ten-Wire Cable	3.25
Cortlandt Panel 7" x 24" x $\frac{3}{16}$" Drilled and Engraved	7.50
Resistor Mounting Strip $1\frac{1}{2}$" x $7\frac{1}{2}$" x $\frac{3}{16}$" Drilled	.50
Baseboard 12" x 23" x $\frac{1}{2}$", Plywood Preferred	.75
Two Rolls of "Braidite" Wire, Two Colors	.60
One Fahnestock Clip and Assorted Screws	.70
Total	$118.25

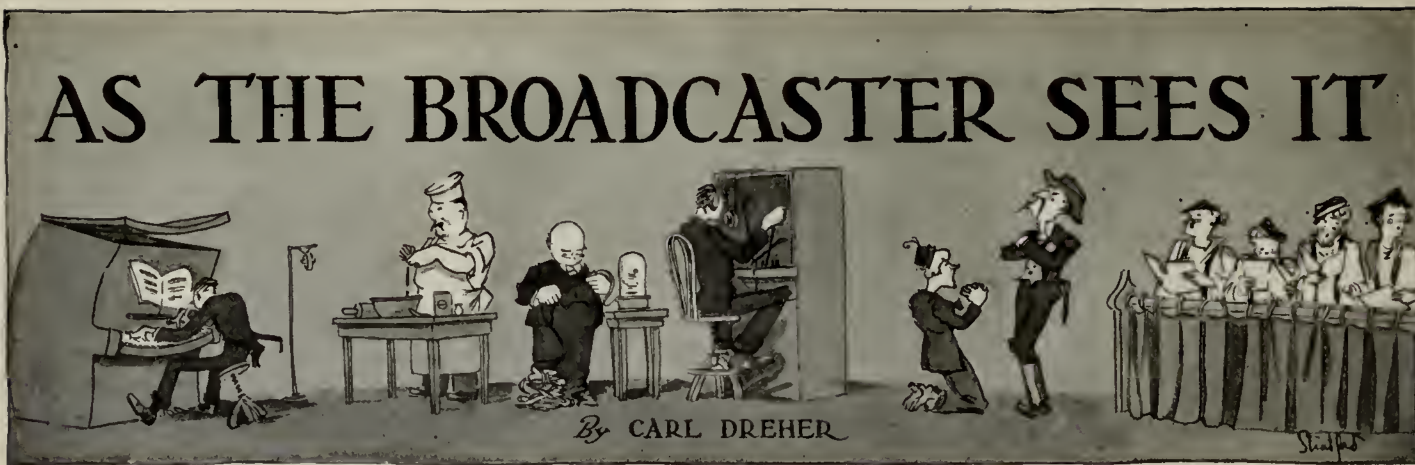
The following additional equipment is partly necessary to operate the receiver. A choice in several instances may be made by the constructor.

Four C-327 Tubes	$24.00
Three CX-326 Tubes	9.00
T_1—SM 325 Filament Transformer	8.00
One S-M 660-210 Power Pack or—	83.50
One S-M 660 171 Power Pack	66.50
One Fritts Cabinet 7" x 24" x 12"	23.50



HOW THE PARTS ARE LAID OUT

The coil units to the left comprise L_2, L_3, L_4, L_5, and L_6, while L_1 is to the right



Design and Operation of Broadcasting Stations

19. Frequency Runs

THE various elements of the circuits used in broadcasting exhibit effects which depend, among other factors, on the frequency of the potentials applied to them. A line, for example, tends to attenuate voice currents of high frequency more than currents of lower frequency, because of the shunting effect of the distributed capacity, which varies with the frequency. More specifically, we may say that every piece of apparatus has a definite transmission characteristic with frequency, which it is necessary to know if organizations of apparatus are to be brought about for given objects, for example, impartial or "flat" reproduction of sounds of different pitches. Such a curve of amplitude against frequency is secured by means of a frequency run. In broadcasting the most common frequency runs are made within the audio band, say between 50 and 10,000 cycles per second, and typical circuit elements which require this sort of investigation are telephone lines and the audio circuits of transmitters. Representative methods of making such tests will be briefly described in this article.

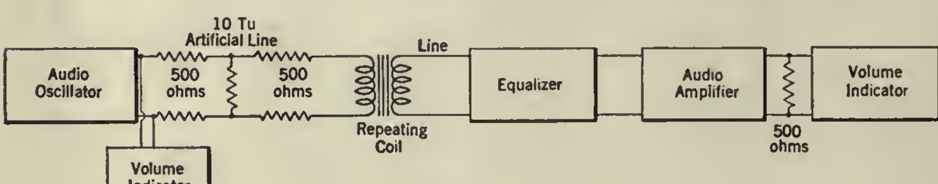


FIG. I

Fig. 1 is a diagram showing how a frequency run may be made on a wire line, using an audio oscillator at the transmitting end and vacuum-tube voltmeters for the indicating instruments. The audio oscillator in all such work must fulfil several requirements. It must cover the frequency range over which the circuit is to be equalized. For ordinary line work, by present standards, this would be from 100 to 5000 cycles, hence the oscillator of Fig. 1 will have to more than cover this band—a 50 to 6000-cycle oscillator would be suitable. The output must be substantially free from harmonics. Obviously since the instrument is to be used in determining frequency characteristics one must be able to secure oscillations of any frequency in the range without the admixture of other frequencies. If, for example, the behavior of the line is to be studied at 200 cycles, the harmonics (400, 600, 800 . . . cycles) must be suppressed. Usually a harmonic amplitude of ½-per cent. is allowable, but the proportion must not be greater. The power output of the oscillator should be reasonably constant over the range of frequency, and it is not difficult to design an oscillator which will meet this requirement within 5 per cent. output voltage variation over a 50 to 10,000-cycle band. The oscillator may be one of several types. One form consists of audio tuned circuits, generally employing fixed condensers and obtaining the frequency variation by means of taps on an iron core coil of suitable inductance. The inductance and capacitance together tune to the audio frequency directly. Another type of audio oscillator utilizes the heterodyne principle. Two radio-frequency oscillators have their outputs combined, rectified, and, if necessary, amplified at audio frequency. Generally one of the component oscillators has its frequency fixed; the other radio frequency is varied, and the beats may be made to cover the whole audible range. Precautions must be taken to avoid too much frequency drift, owing to varying voltages, and there is also a tendency for the two radio oscillators to pull into synchronism at the lower beat frequencies. Some information on the construction of audio beat oscillators for laboratory testing is contained in several 1927 papers in the *Proceedings of the Institute of Radio Engineers* (Wolff and Ringel: "Loud Speaker Testing Methods," May, 1927; Dickey: "Notes on the Testing of Audio-Frequency Amplifiers," August, 1927; Diamond and Webb: "Testing of Audio-Frequency Transformers," September, 1927). In general, broadcasters who lack laboratory training in measurements will do better if they buy such instruments as audio oscillators. Such apparatus is sold by the General Radio Company, Graybar Electric Company, and other concerns. Oscillators covering a range of from 10 to 50,000 cycles, or higher, with definitely known output characteristics, are obtainable. One form covers from 15 to 9000 cycles, continuously variable through a single control; the price is a little more than $200.

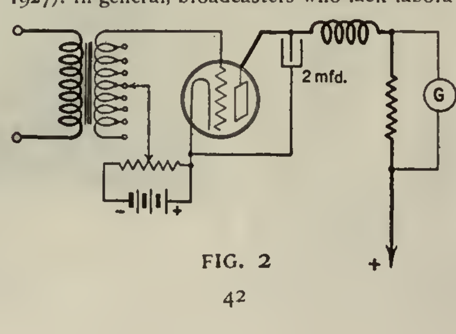


FIG. 2

Returning now to Fig. 1, we note that the receiving instrument is a "volume indicator" of the vacuum-tube type. The circuits of a typical form are shown in Fig. 2. The action will not be taken up in great detail, as a previous article in this series ("Volume Indicators," RADIO BROADCAST, May, 1927) dealt with the general theory. In the form shown the negative grid bias is adjusted until the d.c. galvanometer in the plate circuit of the tube reads 5 scale divisions out of a total of 60 full-scale. Then the tap on the secondary of the input transformer is set to give peak readings, with modulation, of, say, 30 scale divisions. The level of the circuit across which the instrument is bridged may then be read on a scale attached to the transformer tap switch. High levels, obviously, correspond to settings in which only a small portion of the total transformer voltage is utilized, whereas when the telephonic level is low, more of the winding must be included by means of the tap switch in order to get the requisite galvanometer swing. Obviously the readings of such an instrument are the resultant of many factors, such as the wave form of the alternating currents under measurement, the ballistic characteristics of the galvanometer, the size of the galvanometer shunt, the smoothing characteristics of the inductance-capacitance filter in the plate circuit, the type of vacuum tube employed, and other details, but it is possible to design such level indicators to read in telephonic transmission units with sufficient accuracy for the usual purposes of broadcast transmission or measurement. The prototype is the Western Electric 518-B type, which, in its lowest range, from minus 10 to plus 10 TU, is constructed as shown in Fig. 2, but extends the range of measurable levels to as high as plus 40 TU by the addition of a potentiometer arrangement across the secondary of the input transformer.

Obviously a level indicator must always be a bridging instrument, a circuit element, that is, with a relatively high input impedance, intended for connection across circuits of low impedance without drawing enough energy from the low-impedance circuit to affect conditions therein.

The volume indicator described above has an input impedance of about 12,000 ohms and it must be used across a 500- or 600-ohm circuit if its calibration is to hold. It is so connected in the set-up for a line frequency run shown in Fig. 1. The output of the oscillator is of 500 ohms impedance. This feeds a 10-TU artificial line which presents an impedance of 500 ohms in each direction. The usual repeating coil is inserted ahead of the line. The line is assumed to have an impedance of about 500 ohms also. At the other end of the line there is an equalizer (See article on "Types of Equalizers," RADIO BROADCAST, June, 1926) followed by a two-stage amplifier, with an output impedance of 500 ohms. This amplifier must be terminated with a resistance of this magnitude, therefore, before the level readings of a volume indicator bridged across it will be valid.

Since the equalizer is at the far end of the line, the latter will not present a strictly constant impedance at the transmitting end, and this would affect the output of the oscillator if instrument were connected directly to the line. The artificial line acts as a buffer, in that it provides a more constant impedance for the oscillator to feed into; in some cases the artificial line network also permits measurement at more convenient levels without excessive input to the telephone line.

The procedure for a frequency run is obvious from this point on. The oscillator is set at various frequencies, the outgoing level checked with the volume indicator across it, and similar readings taken at the receiving end. A curve of received level against frequency may thus be secured for a given setting of the equalizer. If the equalizer is omitted, and the transmitted level remains constant, such a curve will show the line attenuation characteristic, which is a curve descending with frequency. The object of the equalizer being to correct this loss of the higher frequencies, a number of frequency runs may be taken, until a horizontal curve of received level is secured. The line is then equalized. Communication between the two terminals may be maintained over the line by telephone or telegraph in the intervals between readings, or over a separate pair. Of course before an attempt is made to take a frequency characteristic of a line, or to set the equalizer for a flat characteristic, the usual d.c. wire chief's tests are made for defects like open circuits or grounds. Nothing in the way of audio-frequency testing can be accomplished until such faults have been eliminated.

HOW NOT TO DO IT

FIG. 3 shows a method of taking line frequency runs which is illegitimate. I have seen it used, and so mention it here with the caution that results so secured will usually be misleading. The oscillator, with the volume indicator bridged across it, is connected across a 500-ohm resistance and the level is read. The output of the oscillator is then switched to a line, the equalizer being at the other end. In this way a frequency run is made and the line is thought to be equalized. Actually, as the impedance of the line varies with the frequency, the output of the oscillator will also vary with frequency and the result of the experiment will merely be to show how the oscillator behaves with a variable impedance connected across its terminals.

Sometimes it is convenient to send out tone on a line using the regular broadcast amplifier set-up. For example, in chain operation it is a sound precaution to transmit tones at a number of important frequencies before a program. The network stations take level readings at the various frequencies transmitted, which may be

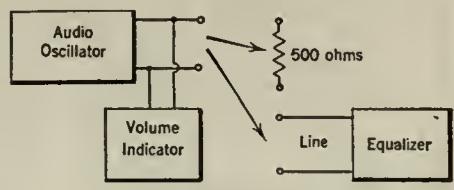


FIG. 3

100, 1000, and 5000 cycles, and telegraph them back as a check on the condition of the lines. Any irregularity will show up in these readings and necessary changes in routing of circuits, adjustment of terminal apparatus, etc., may be made before the program begins. Fig. 4, from the input of the three-stage amplifier, is the usual set-up for broadcasting. The input to the first amplifier would normally be a microphone. For the microphone there has been substituted the audio oscillator, a repeating coil, and a variable attenuation network, which can be adjusted to any loss up to 30 TU. By means of this pad the level of the outgoing tone may be made the same as that normally used during broadcasting—usually around zero level (12 milliwatts on peaks, or about 5 milliamperes into a 500-ohm circuit).

In the December, 1924, issue of the *Proceedings of the Institute of Radio Engineers*, Mr. Julius Weinberger showed a means of taking the audio-frequency characteristic of the modulation system of a radio station. The diagram is reproduced, with some slight modifications, in Fig. 5 herewith. The audio oscillator in this case

FIG. 4

feeds into a 500-ohm resistance, matching its normal output impedance. A thermo-galvanometer in series measures the a.c. emitted by the oscillator. A portion of the voltage across the 500-ohm resistor is fed into the line amplifier of the station with enough added resistance on either side to maintain the 500-ohm impedance. The tone passes through the entire audio-frequency system and the level is measured at the output of the modulators. A fixed condenser of ½-mfd. capacity blocks the direct plate voltage and allows only the audio component to affect the measurement circuits. The lower terminal of the condenser is connected to ground through a resistance of the order of 20,000 ohms, which is so high that the characteristics of the transmitter will be unaffected by the addition of the measuring circuit. A relatively small portion of the audio voltage across the resistor is tapped off for the thermo-galvanometer. A radio-frequency trap is usually required to keep r.f. out of the galvanometer circuit. The current readings of the input and output galvanometers will now give the transmission characteristics of the modulation system at any frequency within the compass of the oscillator. The curve may be drawn with ordinates of percentage of amplitude compared with the transmission of the mean speech frequency (1000 cycles), or in TU, the horizontal axis representing frequency.

The thermo-galvanometers in such a set-up as that shown in Fig. 5 must necessarily have the right full-scale reading for the circuits under measurement. The required capacity can readily be calculated, since the output of the oscillator, the amplification of the audio system, and therefore the alternating voltage developed by the modulators, will all be approximately known. Where there is any doubt a large instrument is first used, until one of the right sensitiveness and current-carrying capacity is found. As the output measurements are made across the full plate voltage the engineer who works on this end must take the usual precautions against accidental contact with the high-tension portions of the equipment.

RADIO FOLK YOU SHOULD KNOW

4. E. B. Pillsbury

IF THERE is a communication man in the United States it is Edward Butler Pillsbury, the Vice President and General Manager, as well as a Director, of the Radio Real Estate Corporation of America, the holding company for the realty properties of the R. C. A. Mr. Pillsbury has spent his entire career in telegraphy, starting as a messenger, working ten years as a Western Union operator, followed by many years in the service of the Postal Telegraph-Cable Company, first as Chief Operator in Boston, then advancing to the grades of local Manager in that city, Assistant Superintendent, District Superintendent for New England, and finally General Superintendent of the Eastern Division of the company, with jurisdiction over the lines and offices in thirteen states from his headquarters in New York. This position Mr. Pillsbury held for six years, until he resigned to take up radio work as General Superintendent of the Transoceanic Division of the Marconi Wireless Telegraph Company of America, and later for the Radio Corporation. In 1922 he was elected to his present office.

While serving as an operator Mr. Pillsbury was renowned as an expert Morse man. He was among the first chief operators to adopt the practice of using the Wheatstone bridge method of locating faults on telegraph lines.

Anyone else who has seen all he has of the communication business and of life would be writing his memoirs. But when Mr. Pillsbury was asked to supply information for this biographical sketch he replied plaintively. "I regret to say that no interesting anecdotes or experiences have come my way." Press agents should thank God that the country is not crowded with Edward Butler Pillsburys.

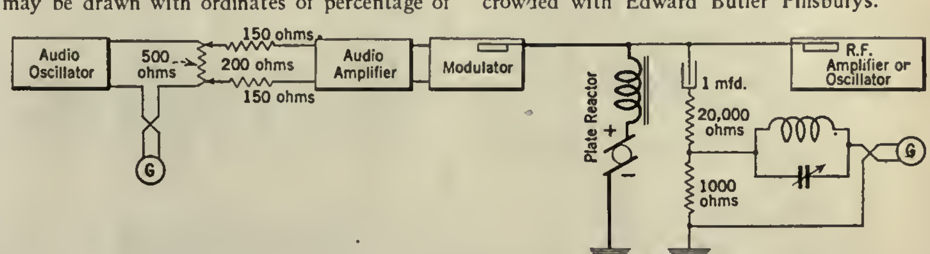


FIG. 5

SHORT-WAVE TRANSMISSIONS

Stations Throughout the World Working Below 100 Meters

THE following list is reprinted from *Wireless World*, London, England, and comprises the stations which transmit fairly regularly on wavelengths below 100 meters. As a result of the recent Radio-telegraphic Conference it is possible that several of these wavelengths may be altered. We shall, therefore, welcome any authoritative information correcting or supplementing that given below.

The stations are arranged alphabetically according to their call-signs, as we believe this will be found the most acceptable method for easy identification. The editors of *Wireless World* have, in the case of experimental stations, omitted the usual continental prefix, but retained that indicating the country (*e.g.*, U 2XAD and not NU 2XAD, and A 2FC not OA 2FC). Where transmissions are sent out at regular times these are in many cases indicated in brackets following the usual wavelength. The list cannot be guaranteed free from inaccuracies since the constant changing of schedules makes it impossible to get up a list which is as correct at the time of its publication as it was at the time of its compilation.

All the times, it will be noted, are given in Greenwich Mean Time (G.M.T.). Greenwich time is five hours ahead of Eastern Standard Time. Thus five o'clock in the evening London time is midday New York time eleven o'clock a.m. Chicago time, ten o'clock a. m. Denver time, or nine o'clock a. m. San Francisco time. G. M. T. runs from 01.00 to 24.00, 01.00 being 1 a.m. and 24.00 being midnight. Thus 13.07 G. M. T. (the same as seven minutes after one o'clock p. m. G. M. T.,) is the equivalent of seven minutes after eight o'clock a.m.E. S. T. While this conflicts with the table supplied by the U. S. Navy Department printed on page 53, it is obvious from a study of some of the known schedules below that it jibes with what was intended by the compiler.

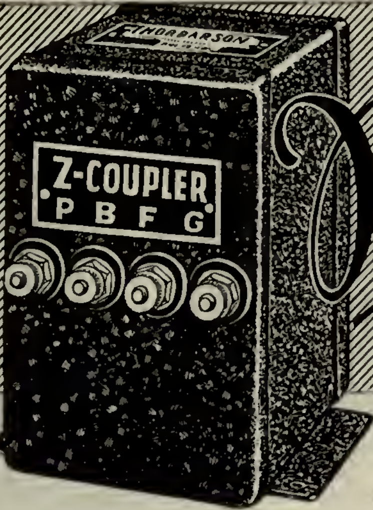
Call-Sign	Station	Wavelengths and Remarks
	A	
AFI	Konigswusterhausen	26.3.
AFJ	Konigswusterhausen	53.5.
AFU	Konigswusterhausen	39.7.
AGA	Nauen	14.9, 12.25, 13.5, 14.25, 16.0, 26.0.
AGB	Nauen	25.5, 26.6, 27.0.
AGG	Nauen	17.2, 26.0, 39.8, 40.2 (*Phone occasionolly*)
AGJ	Nauen	56.7 (*Phone occasionally after 1800 G. M. T.*).
AGK	Nauen	11.0, 20.0 (*2 kw.*).
AIN	Casablanca, Ain Bordja	51.0 (*Weather reports, 0830 and 1930 G. M. T.*).
AKA	German Naval Vessel, M.81	54.0.
AKB	German Naval Vessel, M.82.	54.0.
ANG	Tjililin, Java	26.2, 40.2 (*Code*).
AND	Tjililin, Java	18.8, 28.8, 37.5 (*Code*).
ANDIR	Malabar, Java (Military Aerodrome)	38.5.
ANE	Bandoeng, Java	17.4 (*Code and Phone*).
ANF	Tjililin, Java	20.3, 36.5 (*Code*).
ANH	Malabar, Java	17.4., 27.0, 32.0. (*Code and phone. Phone on Soturdoy, 1200–1700 G. M. T., and at other times as then announced.*).
ANK	Malabar, Java	19.4, 30.20 (*Exp. Tests*).
AQE	SS. *Sir James Clark Ross*	33.5.
ARCX	Norwegian Whaler *Nielsen Alonso*	30.5 (*After 0700 G. M .T.*).
ARDI	SS. *C. A. Lorsen*	32.0.
AYG	Guayra, Venezuela	31.8.
A 2FC	Sydney, N. S. W.	32.0 (*Phone*)
A 2ME	Sydney, Australia	28.50 (*Phone Sun., 1830–2000 G. M. T.*).
A 3LO	Melbourne	29.8, 32 or 36 (*Phone Sun., 1830–2030 G. M. T.*).
	B	
BAM	Tahiti	40.0.
BVJ	R. N. College, Dartmouth	46.0.
BWW	Gibraltar, North Front (Naval Station)	35.0.
BXW	Seletar, Singapore (Naval)	35.0.
BXY	Stonecutters Island, Hong-Kong	35.0.
BYB	Whitehall R. C. (Naval)	35.0.
BYC	Horsea (Naval)	35.0.
BYZ	Rinella, Malta (Naval)	35.0.
BZC	Portsmouth Signal School	35.5.
BZE	Matara, Ceylon (Naval)	35.0.
BZF	Aden (Naval)	35.0.
B82	Uccle, Belgium	40.0.
	C	
CF	Drummondville, Montreal (Beam Station)	32.0 (Temporary).
CG	Drummondville, Montreal	16.501, 32.128.
CH	Quilicura, Chile	15–20.
CRHA	Lourenco Marques, Portuguese East Africa	18.360.
CRHB	Praia, Cape Verde Islands	18.094.
CRHG	Loanda, Angola	18.182.
	D	
DCP	SS. *Cap Polonio* (German)	25.0, 34.0.
DNSC	Royal Danish Dockyard, Copenhagen	47.0.
DS	H. M. S. *Renown*	36.0.
	E	
EAM	Madrid	30.7.
	F	
FAMJ	French SS. *Jeanne d'Arc* (French Navy)	26–60.
FL	Eiffel Tower	32.0, 75.0.
FTJ	SS. *Jacques Cortier* (France).	75.0.
FW	St. Assise, Cie. Radio, France	14.28, 23.25, 25.0, 41.95, 43.0. (*Traffic with Buenos Aires*).
FUA	Bizerta-Sidi-Abdallah, Tunis.	42.5, 56.0, 73.0.
FUE	Mengam, France	38.5.
FUL	Beyrouth-Djedeide, Lebanon.	28.0–80.0.
FUM	Montebourg (Air Station)	37.0.
FUT	Toulon-Mourillon, France	36.5.
F 8GA	Clichy	30.0.
F 8G3	St. Assise, Paris (S.F.R.)	75.0 (*S.F.R. Bulletins*).
F 8GC	Radio LL, Paris	60.0 (*Phone*).
	G	
GBH	Grimsby (Beam Station)	25.906.
GBI	Grimsby (Beam, Indian Circuit)	16.216, 34.168.
GBJ	Bodmin (Beam, S. Africa Circuit)	16.146, 34.013.
GBK	Bodmin (Beam Station)	16.574, 32.397.
GBL	Leafield (P. O. Station)	17.5, 21.5, 24.0, 30.0, 56.0.
GBM	Leafield (P. O. Station)	17.5, 21.5, 24.0, 30.0, 56.0.
GBO	Leafield (P. O. Station)	17.5, 21.5, 24.0, 30.0, 56.0.
GDKB	SS. *Dorsetshire*	24.0, 41.7.
GFA	Air Ministry, London	44.0.
GFR	Winchester (R.A.F. School)	20.0.
GFY	Royal Air Force, Henlow	76.0.
GLG	Royal Air Force, Henlow	15.740, 15.707.
GLH	Dorchester (Beam Station)	22.091 (*American Circuit*).
GLQ	Ongar (for communication with New York, Buenos Aires, and Rio de Janeiro)	24.5.
GLS	Ongar	15.0.
GLSQ	SS. *Olympic*	20.0.
GLW	Dorchester (Beam Station, South American Circuit)	15.707.
GLYX	SS. *Derbyshire*	37.0.
G 2BR	Chelmsford	15.0, 17.0.
G 2NM	G. Marcuse, Caterham	32.5 (*Phone Tues., Thurs., Sat., Sun., 0600–0700, and Sun., 1600–1800 G.M.T.*).
G 2YT	Poldhu	25.0, 32.0, 60.0, 92.0, 94.0.
G 5DH	Dollis Hill (P. O. Station)	21.7, 27.6, 35.3, 47.0.
G 5SW	Chelmsford (B.B.C. Exp.)	24.0 (*Phone 1330, 1430, and 1930 onwords*).
	H	
HBC	Berne, Switzerland	34.2
HJG	Bogotá, Colombia	22.0
HVA	Hanoi, Tonkin	32.0.
HZA	Saigon	25.0.
H 90C	Telegraphic and Radio Service, Case No. 63, Poste Transit, Berne	32.0 (*Relays Berne, Mon., Thurs., and Sat., 2000–2100*).
H 9XD	Radio Club of Zurich	32.0, 85.0.
	I	
ICG	Coltano	18.0.
ICD	Rome (Cento Celle)	63.0.
ICF	Messina, Sicily	49.0.
ICJ	Bengasi, Cyrenaica	26.0, 53.0.
ICK	Tripoli	45.0.
ICO	Derna, Cyrenaica	54.0.
ICU	Tobruk, Cyrenaica	54.0
IGX	Massawa	47.0
IDO	Rome, San Paulo	33.0–37.5.
IDX	Amara, Erythrea	32.5, 64.0.
IHF	Catania, Italy	53.5.
IST	Chisimaio, It. Somaliland	38.0.
I 1AX	Rome, Via Savoia 80	45.0 (*Phone occasionolly*).
I 1FC	Royal Frederico Cesi School, Rome	33.0, 34.0.
I 1MA	Rome, Via Bramante 3	43 (*Sundays, 1700–1930 G.M.T.*).
I 1RG	"Radiogiornale," Lake Como	10.0, 18.0, 35.0, 65.0.

Call-Sign	Station	Wavelengths and Remarks
	J	
JB	Johannesburg	32.0 (*Phone*).
JBK	Kagoshima, Japan	30.0, 40.5, 70.0.
JES	Osaka, Japan	24–71.
JEW	Osaka, Japan	24–71.
JFAB	Taipeh, Formosa	39.5 (*0900 G.M.T.*).
JHL	Hiroshima, Japan	32.0, 58.0, 74.0.
JKV	Kanasawa, Japan	37.5 (Temporary).
JKZB	Tokyo Electric Co.	20.5.
JOC	Otchishi, Japan	43.0.
JPP	Tokyo, Japan	16–73.
JPS	Sapporo, Japan	29.0, 38.0, 60.0.
JYB	Tokyo, Japan	16–73.
JYZ	Tokyo, Japan	16–73.
J 1AA	Iwatsuki, Japan	40.5.
J 1PP	Tokyo	20.0, 21.5, 35.0.
	K	
KAV	Norddeich	39.0, 68.0.
KDKA	East Pittsburgh, Pa. (Westinghouse E. & M. Co.)	26.3. 42.95, 62.5 (*Phone from 2300 G.M.T.*).
KDO	SS. *Esparta* (United Fruit Co. U. S. A.)	33.0.
KDZ	Point Barrow, Alaska	21.4, 42.08, 74.77.
KEB	Oakland, Calif. (G. E. Co.)	18.62, 21.8.
KEG	Vancouver, Washington (Pacific Air Transport)	45.0.
KEL	Bolinas, Calif. (R.C.A.)	14.1. 29.3, 95.0.
KEMM	Bolinas, Calif. (R.C.A.)	14.29, 28.58.
KESS	Bolinas, Calif. (R.C.A.)	14.40, 28.80.
KET	Bolinas, Calif. (R.C.A.)	99.0.
KEU	Los Angles, Calif. (Pacific Air Transport)	45.02
KEUN	Bolinas, Calif. (R.C.A.)	14.08, 38.38.
KEWE	Bolinas, Calif. (R.C.A.)	14.08, 28.15.
KFD	Denver, Colorado (G.E. Co.)	17.7, 24.3.
KFHW	SY. *Poinsettia*	40.0.
KFQU	Holy City, Calif.	31.0, 53.0, 63.0.
KFVM	SS. *Idalia*	17.0, 37.0, 74.0.
KFWB	Los Angeles, Calif.	40.0.
KFY	Poinciana, Florida	68.4.
KFZG	Port Barrow	45.32, 69.25.
KFZH	Fairbanks, Alaska	44.71, 68.32.
KFZQ	SS. *Robador*	37.5.
KGBB	U. S. SS. *Ungava* (R. B. Metcalf)	22.0, 37.0.
KGDU	SS. *Four Winds*	35.03.
KGE	Medford, Oregon (Pacific Air Transport)	46.06.
KGFT	Portable Station, Texas	50.0.
KGH	Hillsbro', Oregon (Fed. Telegraphic Co.)	36.52, 46.99.
KGT	Fresno, Calif. (Pacific Air Transport)	46.06.
KIO	Kahuku, Hawaii (R.C.A.)	90.04.
KKC	Palo Alto, Calif. (Fed. Telegraphic Co.)	17.0, 27.5.
KLL	Bolinas, Calif. (R.C.A.)	21.85.
KMM	Bolinas, Calif. (R.C.A.)	14.29, 28.58.
KMV	Bandini, Calif. (Western Air Express Inc., Morse)	49.5.
KNN	Honolulu (Mackay, R. & T. Co.)	17.2, 23.0, 23.7, 28.0, 34.4, 46.0, 47.4, 56.0.
KNR	Clearwater, Calif. (Fed. Telegraphic Co.)	29.5, 49.15.
KNW	Palo Alto, Calif. (Mackay, R. & T. Co.)	16.7, 17.0, 24.0, 33.4, 34.0, 48.0, 51.0.
KQS	Lone Pine, Calif. (City of Los Angeles)	45.77.
KQT	Los Angeles, Calif. (City of Los Angeles)	45.77.
KRP	Salt Lake City, Utah (Western Air Express Inc.)	49.5.
KSS	Bolinas, Calif. (R.C.A.)	14.40, 28.80.
KSZ	McCamey, Texas	48.05.
KTA	Guam (Mackay R. & T. Co.)	18.0, 21.8, 22.0, 23.5, 36.0, 43.6, 44.0, 47.0.
KTF	Midway Island (Mackay R. & T. Co.)	21.6, 33.2, 43.2, 66.4.
KUN	Bolinas, Calif. (R.C.A.)	16.93, 33.88.
KUY	Bear Creek, Alaska	82.0.
KVR	Las Vegas, Nevada (Western Air Express Inc.)	49.5.
KWE	Bolinas, Calif. (R.C.A.)	14.08, 28.15.
KWJJ	Portland, Oregon	53.54 (½*kw.*).
KWT	Palo Alto, Calif. (Fed. Telegraphic Co.)	34.86, 48.05, 49.97, 58.10.
KWV	Bakersfield (Pacific Air Transport)	66.48
—	Lyons. Radio Lyon	39.5 (*Phone 1700–1800 G. M. T., except Sundays*).
	L	
LA 1E	Meteorological Hut, Bergen	43.0.
LA 1M	Meteorological Inst., Oslo	45.0.
LCHO	Telegraph Administration, Oslo	33.0.
LPI	Buenos Aires	34.0.
LPZ	Buenos Aires	36.0, 75.0.
LY	Bordeaux, Lafayette	32.0.
—	Matagora (Spain), Cie. Transatl. Espagnola	70.0.
	N	
NAA	Washington	24.9, 37.4, 74.7.
NAJ	Great Lakes, Illinois	40.0, 76.0, 34.0.
NAL	Navy Yard, Washington, D. C.	20.0, 30.6.
NAS	Pensacola, Florida	40.0.
NBA	Balboa, Canal Zone	54.0.
NEL	Lakehurst, N. J.	80.0.
NEPQ	U. S. SS. *Relief*	20.0.
NERM	U. S. SS. *Las Angeles*	70.0–84.5.
NFV	U. S. Marine Corps, Quantico, Va.	77.4, 77.5.
NIRX	U. S. SS. *Canopus*	75.0.
NKF	Naval Lab., Bellevue, Anacostia	16.0, 17.0, 20.8, 21.0, 25.5, 41.3, 54.4, 61.0, 71.3, 81.5.
NKL	Arlington	29.0, 37.4, 74.7.
NOSN	U. S. Submarine Base, Coco Solo, Panama	40.0.
NPC	Puget Sound, Washington	37.0.
NPG	San Francisco, California	16.49, 32.98.
NPL	U. S. Training Ship, San Diego, California	71.7.
NPM	Honolulu, Hawaii	35.0 and 36.8.
NPO	Cavite, Philippine Islands	68.0, 70.0.
NPU	Tutuila, Samoa	37.0–40.0, 53.0.
NQC	San Diego, California	75.0, 86.0.
NQW	U. S. SS. *Mexica*	40.0.
NRRG	Winter Park, Florida	39.5, 82.0.
NRRL	U. S. SS. *Seattle*	40.0.
NUQB	U. S. SS. *Pope*	75.0.
	O	
OCBA	Bamako (Soudan)	41.50.
OCBV	French Military Station at Beyreuth	58.0.
OCCO	Conakry (French W. Africa)	33.0.
OCDA	Dakar (French W. Africa)	35.0.
OCDB	Djibouti	72.0.
OCDJ	Issy-les-Moulins	33.0 (*1008–1028 G.M.T.*), 65.0 (*Corresponding with OCDB*), 32.0 (*Time Signal, 0756 and 0955*).
OCMV	French Military Station, Mont Valerien, Suresnes (Seine)	39.0, 44.0, 46.0 (*At 1000, 1100. 1230, 1330, 1600, 1900, 2000, 2100 and 2200 G. M. T., on either 600 cycles or D. C.*).
OCNG	Nogent-le-Rotrou	29.0, 32.0, 45.0, 48.0, 72.0.
OCRB	Rinck, Meteo Aviation, Rabat, Morocco	36.0.
OCRF	Reggu, Morocco	74.0 (*2130–2145 G.M.T.*).
OCRU	Rufisque (French West Africa)	39.0.
OCTN	Mourillon, Toulon	20.0 (*Series of "a" from 1530–1540 G.M.T.*), 33.0 (*Series of "b" from 1545–1555 G.M.T.*), 57.0 (*Series of "c" from 1600–1610 G.M.T. daily, except Sundays*).
OCTP	The Military Station of Nogent-le-Rotrou.	—
OCTU	Tunis la Casbah	48.0, 50.0.
OHK	Vienna	39.5, 40.6.
OLQ	SS. *Slamat*	19.0, 22.5, 37.0.
—	Paris, Radio LL	61.0 (*Phone*).
—	Paris, Radio Vitus	37.0 (*Phone Wed., Fri., Sun., 2100–2245 G.M.T.*).
	P	
PCA	Amsterdam	33.33.
PCG	Malabar, Java	17.0.
PCH	Scheveningen Port	20.0, 20.6, 20.69, 21.127, 28.800, 29.226, 29.283.
PCJJ	Hilversum, Holland (Philips Lamp Works)	30.2 (*Phone*).
PCLL	Kootwijk, Holland	46.0, 32.0, 18.0 (*Wed., 1400–1600 G.M.T. and occasionally on Mon. and Fri.*) and other wavelengths below 60 meters (*40kw*).
PCMM	Ministry of Posts and Telegraphs, Kootwijk	25.0, 27.5, 36.0 and other wavelengths below 60 meters.
PCPP	Kootwijk, Holland	27.0 and other wavelengths below 60 meters.
PCRR	Kootwijk, Holland	20.0, 25.0, 37.0 and other wavelengths below 60 meters.
PCTT	Kootwijk, Holland	21.0, 29.5 and other wavelengths below 60 meters (*10 kw.*).
PCUU	Dutch Colonial Ministry. The Hague	31.0.
PKD	Koepang	32.0.
PKE	Amboina	24.0.
PKH	Soerahaja, Java (D.E. Indies)	23.0.
PKP	Medan	21.5, 31.5.
PKX	Java	27.0, 32.0.
POF	Nauen	13.5, 18.0.
POX	Nauen	20.0.
POY	Nauen	25.0.
POZ	Nauen	47.0.
POS	Alfragidi, Lisbon (Beam)	18.270.
PQW	Alfragidi, Lisbon (Beam)	15.641.
PTQ	Quartel-General, Brazil	30.5.
PVC	Curacao	15.0–20.0.
	R	
RABL	Habarousk	22.0.
RAU	Tashkent	23.0, 34.0.
RCRL	Central Lab., Leningrad	27.0.
RCT	Sebastopol	64.0.
RDI	Petrozavodsk	34.2.
RDRL	Leningrad	28.5.
RDW	Moscow	83.0.
RKV	Moscow	21.0, 34.0.
RLT	Tommot	23.0.
RRP	Nijni Novgorod	20.0–42.0.
RTRL	Tiflis	22.0–42.0.
	S	
SAA	Karlskrona	44.0.
SAB	Goteborg	36.5.
SAD	Flottans Stations, Stockholm	31.0–51.0.
SAJ	Karlesborg, Sweden	50.0.
SDK	SS. *Kiruna*	54.0.
SFR	Paris	75.0, 85.0.
SGT	Motorship *Suecia*	42.0, 50.0.
SIC	SS. *Masilia*	42.0, 51.5.

Stations Throughout the World Working Below 100 Meters

(Continued)

Call-Sign	Station	Wavelengths and Remarks
	S	
SKB	Motorship *Gripsholm*	37.5.
SMHA	Stockholm	41.0.
SOJ	Brazilian SS. *Jaquaraa*	100.0.
SOK	Moskwa Sokoleniki Radio	37.0.
SPM	Radio Laboratory, Ministry of Posts, Helsingfors	47.0.
SPR	Sepetiba, Rio de Janeiro, Brazil	22.180 (*Meteorological reparts, 1530 local time*).
SPU	Santa Cruz (Beam)	15.576.
SPW	Rio de Janeiro	29.3.
SPX	Rio de Janeiro	40.5.
SP 1	Rio de Janeiro	17.0, 44.5, 47.0.
SUC 2	Abuzabal (Cairo)	47.0.
	T	
TFA	Reykjavik, Iceland	42.5, 49.5.
TSB	Norwegian SS. *Helder*	46.5, 51.0.
TUK	Tomsk, Siberia	20.0.
TVE	SS. *Solderijk*	31.0.
	U	
U 1XAO	Belfast, Maine	40.0, 56.0, 60.0, 70.0.
U 1XAB	Portland, Maine (Congress Square Hotel Co)	63.79 (*250 Watts*).
U 1XR	Manila, Philippine Islands	30.0.
U 2XAA	Houlton, Maine	22.99 (*Phone after 2300 G.M.T.*).
U 2XAC	G. E. Co., Schenectady, N. Y.	50.0.
U 2XAD	G. E. Co., Schenectady, N. Y.	21.96 (*Phone Mon., Wed., Fri., 2300; Sat., 1900–2200 G. M. T.*).
U 2XAF	G. E. Co., Schenectady, N. Y. transmitting program from WGY	32.7 (*Phane Tues., Thurs. and, Sat., 2300 G. M. T.*).
2XAI	Newark, N. J. (Westinghouse Electric Co.)	43.0.
2XAL	New York, short-wave transmitter of WRNY (Experimenter Publ. Co.)	30.91.
U 2XAO	Belfast, Maine	40.0, 56.0, 60.0, 70.0.
U 2XAP	New York (Bull Insular Line)	18.3, 18.7, 36.6, 37.5.
U 2XAW	G. E. Co, Schenectady, N. Y.	3.0–20.0, 15.0.
U 2XBA	Newark, N. J. (Short-wave Station of WAAM)	65.18 (*Phane Mon., Wed., Fri.. 2355–0500 G. M. T.*)
U 2XBB	New York (R. C. A.)	1–5 (*1kw.*)
U 2XBC	Rocky Point, N.J. (R.C.A.)	14.09 and 5.35–18.74.
U 2XBI	Rocky Point, N. Y. (R.C.A.)	1–15 (*10 kw.*).
U 2XE	Richmond Hill, N. Y. (Short-wave of WABC)	22.1 (*Phone after 2300 G.M.T.*)
U 2XG	Rocky Point, N. J. (Western Electric Co.)	16.02 (*Phone Man. and Fri. after 1700 G.M.T.*).
U 2XH	Schenectady, N. Y.	50.0.
U 2XI	Schenectady, N. Y.	30.0, 35.0, 38.0.
U 2XK	South Schenectady, N. Y. (General Electric Co.)	65.5.
U 2XN	Rocky Point (R.C.A.)	5–80 (*150 Watts*).
U 2XS	Rocky Point (R. C. A.)	14.93 (*80kw.*)
U 2XT	Rocky Point, N. Y. (R.C.A.)	16.17 (*80 kw.*).
U 3XL	Bound Brook, N. J.	60.0 (*30 kw.*).
U 3XQ	Mountain Lakes, N. J.	37.95, 75.9.
U 4XK	San Juan, Porto Rico (Bull Insular Line)	18.3, 18.7, 36.6, 37.5.
U 5XH	New Orleans (Tropical Radio Telegraphic Co.)	42.0.
U 6XAI	Inglewood, California	66.04 (*Phone 2400 G.M.T., anwards*).
	U	
U 6XAR	San Francisco, California	33.00 (*Phone 2400 G.M.T. anwards*).
U 6XI	Bolinas, California	29.3.
U 6XO	Kahuhu, Hawaii	90.0.
U 8XJ	Columbus, Ohio	54.02.
U 8XK	East Pittsburgh (Westinghouse Co.)	26.8 (*Man. and Fri. 1900–2100 G.M.T.*).
U 8XS	East Pittsburg, Pa	67.0, 96.0.
U 9XU	Council Bluffs, Iowa	61.06. (*Phane*).
	V	
VAS	Louisburg, Nova Scotia	52.0 (*Press Reparts*).
VGJL	SS. *Canadian Commander*	43.0.
VIS	Sydney	22.0, 26.0, 32.0, 42.0, 51.5
VIT	Townsville, Queensland	22.0, 42.0.
VIZ	Ballan, Melbourne (Beam Station)	25.728.
VJZ	Rabaul, New Britain	22.0, 26.0, 32.0, 42.0.
VKQ	Garden Island, Sydney	35.0.
VNB	Klipheuval, South Africa (Beam)	16.077, 33.708.
VQF	Kuching, Sarawak	32–38.
VWZ	Kirkee, Bombay (Beam)	16.286, 34.483.
VZDK	SS. *Jervis Bay*	33.0.
	W	
WABC	Richmond Hill, N. Y. (Atlantic Broadcasting Cpn.)	64.0.
WAJ	Rocky Point, N. Y. (R.C.A.)	22.24, 44.48.
WAQ	Newark, N. J. (Westinghouse Elec. & Mfg. Co.)	44.03.
WBO	Dearborn, Mich. (Ford Motor Co.)	44.62.
WBU	Rocky Point, N. Y. (R.C.A.)	14.09.
WBZ	Springfield, Mass. (Westinghouse E. & M. Co.)	50.0, 70.0, (*20 kw.*).
WCFL	Chicago, Ill. (Fed. of Labor)	37.24.
WCGB	Brooklyn, N. Y.	54.0 (*¼ kw.*).
WCSH	Portland, Maine	63.79 (*¼ kw.*).
WDJ	Harrison, Ohio (Crosley Radio Corporation)	21.4, 26.3.
WDS	Rocky Point, N. Y. (R.C.A.)	15.86, 31.73.
WEAJ	Rocky Point, N. Y. (R.C.A.)	22.24, 44.48.
WEAO	Columbus, Ohio (Ohio State University)	54.02.
WEDS	Rocky Point, N. Y. (R.C.A.)	15.86, 31.73.
WEEM	Rocky Point, N Y. (R.C.A.)	16.41, 32.84.
WEFX	Rocky Point, N. Y. (R.C.A.)	15.79, 31.39.
WEGT	S. Juan, Porto Rico (R.C.A.)	21.75, 65.3.
WEHR	Rocky Point, N. Y. (R.C.A.)	15.93, 31.96.
WEM	Rocky Point, N. Y. (R.C.A.)	16.41, 32.84.
WEOP	Rocky Point, N. Y. (R.C.A.)	21.57, 43.14.
WEP	Cape Charles, Virginia (Norfolk Cape Charles Radio Telegraph Co.)	99.9.
WEPE	Rocky Point, N. Y. (R.C.A.)	21.63, 43.33.
WEQA	Rocky Point, N. Y. (R.C.A.)	14.13, 28.26.
WEQB	Rocky Point, N. Y. (R.C.A.)	16.71, 33.42.
WEQC	Rocky Point, N. Y. (R.C.A.)	16.78, 33.37.
WEQX	Rocky Point, N. Y. (R.C.A.)	14.85, 29.71.
WEQY	Rocky Point, N. Y. (R.C.A.)	14.91, 29.83.
WFV	Poinciana, Florida (Florida RT Co.)	70.54.
WFX	Rocky Point, N. Y. (R.C.A.)	15.70, 31.59.
WGI	Alpena, Mich. (Alpena Marine Radio Service)	98.3.
WGT	S. Juan, Porto Rica (R.C.A.)	21.75, 65.3.
WGW	Vieques, Porto Rico (Bureau of Insular Telegraphs)	52.0.
	W	
WGY	Schenectady, N. Y. (G. E. Co.)	35.0.
WHD	Sharon, Pa. (Westinghouse Co.)	49.0.
WHK	Cleveland, Ohio	66.04 (*¼ kw.*).
WHR	Rocky Point, N. Y. (R.C.A.)	15.93, 31.96.
WHW	Highland Park, Ill. (Wireless Telegraph & Communication Co.)	45.02.
WIK	New Brunswick, N. J.	21.48, 21.5.
WIR	New Brunswick, N.J.(R.C.A.)	74.0 (*20 kw.*).
WIZ	New Brunswick, N.J.(R.C.A.)	43.35 (*Phone occasionally fram 2300 G.M.T.*).
WJD	New York International News Service	37.01.
WJZ	Boundbrook, N. J. (R. C. A.)	18.17.
WKC	Newark, N. J.	17.5, 27.9.
WKI	Newark, N. J. (Fed. Telegr. Co.)	17.3, 27.9.
WKK	Cuba, Porto Rico (Bureau of Insular Telegraphs)	52.0
WLL	Rocky Point, N. Y. (R.C.A.)	16.57
WLW	Cincinnati, Ohio (Crosley Radio Corporation)	52.02 (*2200-0400 G.M.T. except Fri.*).
WNBT	Elgin, Illinois	33.5 (*Special Time Signals*).
WND	Ocean Township, N. J. (American Telephone & Telegraph Co.)	13.88, 16.35, 22.38, 32.69, 46.48.
WNU	New Orleans, Louisiana	26.0, 40.0 (*Press Reports*).
WOBD	SS. *Radia*	37.0, 43.74, 77.0.
WOBV	U. S. SS. *Nippekantu*	36.2, 72.4.
WOP	Rocky Point, N. Y. (R.C.A.)	21.57, 43.14.
WOWO	Fort Wayne, Indiana (Main Auto Supply Co.)	22.80 (*1 kw.*) (*Phane after 2300 G.M.T.*).
WPE	Rocky Point, N. Y. (R.C.A.)	21.63, 43.14.
WQA	Rocky Point, N. Y. (R.C.A.)	14.13, 28.26.
WQB	Rocky Point, N. Y. (R.C.A.)	16.71, 33.42.
WQC	Rocky Point, N. Y. (R.C.A.)	16.78, 33.57.
WQN	Rocky Point, N. Y. (R.C.A.)	51.5, 54.5, 57.0.
WQO	Rocky Point, N. Y. (R.C.A.)	35.03, 44.0.
WQQ	Rocky Point, N. Y. (R.C.A.)	14.8.
WQX	Rocky Point, N. Y. (R.C.A.)	14.85, 29.71.
WQY	Rocky Point, N. Y. (R.C.A.)	14.91, 29.83.
WRB	Miami, Florida (Florida Radio Telegraph Co.)	70.74.
WRNY	Coteysville, N. J. ("Radio News")	30.91 (*Phone Mon., Wed., Fri., 1930–2215 G.M.T.; other days, 2355–0500*).
WSS	Rocky Point, N. Y. (R.C.A.)	16.0, 20.0.
WTT	Rocky Point, N. Y. (R.C.A.)	16.02.
	X	
XDA	Mexico City, Mexico	34.0 (*Press Reports, 0500 G.M.T.*).
XEK 4AP	German Aeroplane	42.5.
	Y	
YZ	Fort d'Issy, France	45–47.
	Z	
ZWT	Bremerhaven	53.0.
ZZ	Fort d'Issy (Portable)	45–47



New! SCREEN-GRID Audio Amplification

The Thordarson Z-Coupler, a special audio impedance coupler for use with screen grid tubes; price each, $12.

Screen grid audio amplification, most revolutionary development in audio systems since the introduction of the power tube, is now an established fact.

The Thordarson Z-Coupler is a special audio coupling device designed for use with the screen grid tube UX-222. With the remarkable amplification thus obtained a mere whisper from the detector is stepped up to a point that gives the power tube all it can handle in the way of signal voltage. In fact, one stage Z-Coupled audio has the amplification equivalent of two, or even three, stages of ordinary coupling. Signals barely audible before may now be heard at normal room volume.

In tone quality, too, the Z-Coupler is unexcelled. Despite the high amplification the tonal reproduction is as nearly perfect as any audio amplifier yet developed. Both high and low notes come through with the same volume increase. Even at 60 cycles the amplification is over 95% of maximum.

Regardless of the type of your receiver you can vastly improve its performance by including this new system of amplification. The Z-Coupler replaces the second audio transformer, with very few changes in the wiring. The screen grid tube is used in the first audio stage. No shielding is required.

THORDARSON Z-COUPLER

THORDARSON ELECTRIC MANUFACTURING CO.
Transformer Specialists Since 1895
WORLD'S OLDEST AND LARGEST EXCLUSIVE TRANSFORMER MAKERS
Huron and Kingsbury Streets ~ Chicago, Ill. U.S.A.

Write To-Day for Complete Information

THORDARSON ELECTRIC MFG. CO.
Huron and Kingsbury Sts., Chicago, Ill.
Gentlemen:

Without obligation on my part, please send me complete information on screen grid audio amplifiers using your new Z-Coupler. (3578-J)

*Name*______________________

*Street and No.*______________________

*Town*______________ *State*__________

The *Radio Broadcast*

LABORATORY INFORMATION SHEETS

THE RADIO BROADCAST Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4" x 6" filing cards, or in a notebook. The cards should be arranged in numerical order. In July, 1927, an index to all Sheets appearing up to that time was printed. This month we print an index covering the sheets published from August, 1927, to May, 1928, inclusive.

All of the 1926 issues of RADIO BROADCAST are out of print. A complete set of Sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Some readers have asked what provision is made to rectify possible errors in these Sheets. In the unfortunate event that any serious errors do occur, a new Laboratory Sheet with the old number will appear

—THE EDITOR.

No. 185 RADIO BROADCAST Laboratory Information Sheet **May, 1928**

Tube Overloading

EFFECT OF INCORRECT VOLTAGES

DURING recent years many familiar types of radio tubes have played the rôle of "Jack of all trades," and as a result have frequently been placed in service under conditions never intended or contemplated by the manufacturer.

What constitutes "overload" on a tube, resulting in shortened life? It might be imagined that the last tube in a receiver tuned-in on a strong local station, and with the volume turned up beyond the point where the music sounds clear, would fall under this classification, but this is not the case. This is a form of overloading, but one which only results in distorted music, and in general the tube is not affected at all. A severe overload permanently affecting the tube occurs, however, when the manufacturer's specifications as regards filament, plate, and grid voltages are disregarded and higher voltages are used.

One of the popular tube types affords a good illustration of this condition. The voltages recommended for type 201-A tubes are a filament voltage of 5.0 volts, and plate voltages of 90 to 135 volts, with the grid bias specified as −4.5 and −9.0 volts respectively. If the grid bias of 4.5 volts recommended at 90 volts is omitted it is equivalent to adding about 35 volts to the plate voltage, or in other words, is equivalent to operation of the tube at 125 volts with −4.5 volts bias. The overload is, of course, correspondingly more severe if the plate voltage is raised. This is clearly shown in the table below:

PLATE VOLTS	GRID VOLTS	CURRENT M A.	EXTENT OF OVERLOAD
90	4.5	2.0	Below maximum
135	9.0	2.5	Normal
90	0	6.0	58%
120	0	9.8	240%
135	0	12.0	380%

The 201-A type tube is capable of withstanding some overload more successfully than other types of tubes, but as a general rule it is always advisable to follow the manufacturer's ratings regarding tube voltage.

No. 186 RADIO BROADCAST Laboratory Information Sheet **May, 1928**

The UX-250 and CX-350

A NEW POWER AMPLIFIER

THE UX-250 (CX-350) is the latest tube designed for use as a power amplifier to supply large amounts of undistorted power for the operation of loud speakers. The large output obtainable from this tube prevents any possibility of overloading of the last stage of an audio amplifier.

The filament rating is 7.5 volts, 1.25 amperes. The material used in the filament is the rugged coated ribbon form, similar to that used in the UX-280 (CX-380) rectifier, the filament operating at a dull red. The filament current may be supplied from the 7.5-volt winding of a power transformer. The low operating temperature and the increased size of this type of filament results in minimum ripple voltage or "hum."

It should be noted that, although the filament and plate voltages are the same as those for the UX-210 (CX-310) tube, the plate current is 55 milliamperes at a plate voltage of 400 volts whereas under similar conditions, the plate current of the UX-210 (CX-310) is only 18 milliamperes. The grid voltages for these two tubes, at a plate voltage of 400 volts, are respectively −70 and −31.5, the larger voltage being necessary on the UX-250 (CX-350) tube. Because of the higher plate current and grid bias required by this new tube it cannot always be used to replace the UX-210 (CX-310) tube without changing the circuit.

	RECOMMENDED				MAXIMUM	
Plate Voltage	250	300	350	400	450	Volts
Negative Grid Bias	45	54	63	70	84	Volt
Plate Current	28	35	45	55	55	Milliamp.
Plate Resistance (a.c.)	2100	2000	1900	1800	1800	Ohms
Mutual Conductance	1800	1900	2000	2100	2100	Micromhos
Voltage Amplification Factor	3.8	3.8	3.8	3.8	3.8	
Max. Undistorted Power Output	900	1500	2350	3250	4650	Milliwatts

Filament 7.5 Volts 1.25 Amperes
Max. Overall Height 6¼" Diameter 2 11/16"
Base: Large Standard UX (CX)

Why not subscribe to *Radio Broadcast?* By the year only $4.00; or two years $6.00, saving $2.00. Send direct to Doubleday, Doran & Co., Inc., Garden City, New York.

No. 187 RADIO BROADCAST Laboratory Information Sheet May, 1928

Grid Bias

HOW TO CALCULATE BIAS

THIS Laboratory Information Sheet gives some information regarding grid bias and how it depends upon the voltage of the grid battery and the manner in which the filament circuit of the tube is wired.

The bias voltage on the grid of a tube is always specified with respect to the negative end of the filament. In drawing A of the diagram on Sheet No. 188, the grid voltage is zero.

In drawing B, the filament resistance *R* has been placed in the negative leg of the filament, and since the drop across this resistance is 1.0 volt, the grid bias is also −1.0 volt.

In drawing C, a 4½-volt battery has been introduced in the circuit so that the grid bias is now equal to the voltage of this battery plus the voltage drop across the resistance *R*. The bias is therefore −4½ plus −1.0 or −5½ volts.

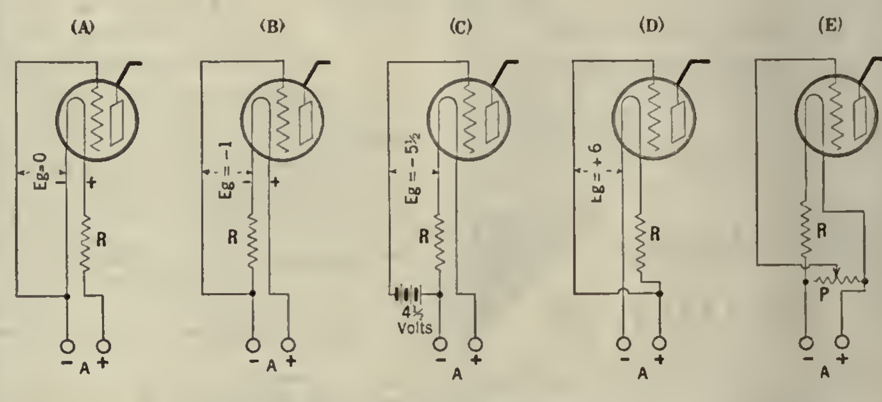
A positive grid bias of +6.0 volts is obtained if the resistance *R* is connected in the positive leg of the filament and the grid return is connected to the +A terminal of the battery. See sketch D. If the grid return was connected to the other leg of the resistance, the grid bias would be equal to the voltage drop in the filament or +5.0 volts.

A variable grid bias from −1.0 to +5.0 volts can be obtained by means of the potentiometer *P* in drawing E. With the potentiometer at the extreme left-hand position, the bias is −1.0 volt (due to the voltage drop in *R*) and with the arm moved over to the extreme right-hand position the bias is +5.0 volts.

From the information given in this Sheet it should be possible to determine the grid bias with any circuit arrangement.

No. 188 RADIO BROADCAST Laboratory Information Sheet May, 1928

Grid Bias Calculations



Laboratory Sheet No. 187 explains these five circuit arrangements. Determination of the grid bias of any circuit arrangement is a simple matter once the information contained on these sheets is mastered

No. 189 RADIO BROADCAST Laboratory Information Sheet May, 1928

The A. C. "Universal" Receiver

PARTS REQUIRED

LABORATORY Sheet No. 190 gives the circuit of the "Universal" receiver wired for a.c. operation. The d.c. receiver was described in the December, 1926, RADIO BROADCAST and the circuit of the d.c. receiver was also given on Laboratory Sheet No. 100, June, 1927. The a.c. circuit is published in response to many requests from readers.

L_1—*Antenna coil* consisting of 13 turns of No. 26 d.s.c. wire wound at one end of a 2¾-inch tube.

L_2—*Secondary coil* consisting of 50 turns of No. 26 d.s.c. wire wound on the same tube as L_1. The separation between L_1 and L_2 should be ⅛ inch.

L_3—*Primary of interstage coil* constructed in same manner as L_1 and tapped at the exact center.

L_4—*Secondary winding* constructed in same manner as L_2 and tapped at point A, the 15th turn from that end as L_4 which is nearest to L_3.

C_1, C_2—Two 0.0005-mfd. *variable condensers.*

C_3—*Neutralizing condenser*, variable, 0.000015 mfd.

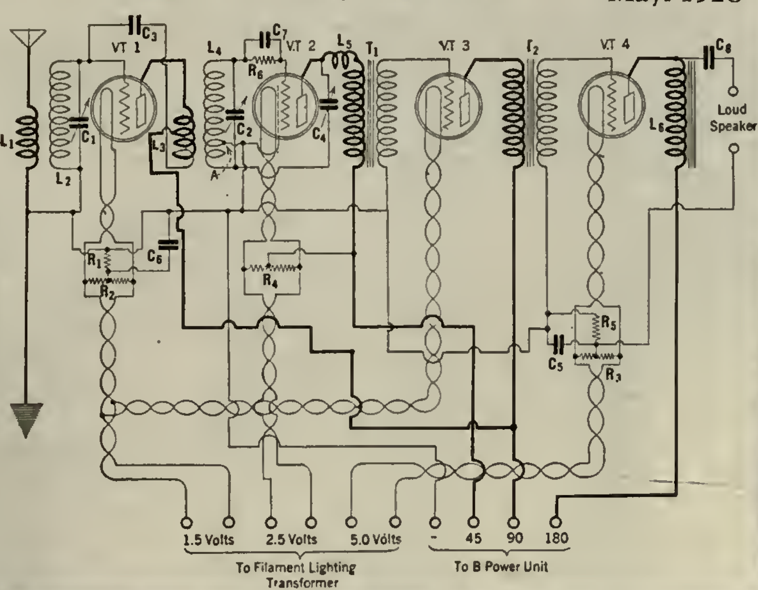
C_4—*Regeneration condenser*, 0.00005 mfd.

L_5—*R.F. choke coil*, made by winding 400 turns of No. 28 wire on ½" dowel.
T_1, T_2—Two *audio-frequency transformers.*
R_1—*Fixed resistance*, 1000 ohms.
R_2, R_3, R_4—*Center-tapped resistances* for a.c. tubes.
R_5—*Fixed resistance*, 2000 ohms.
R_6—*Grid leak*, 2 megohms.
C_6, C_8—*Bypass condensers*, 1-mfd.
C_7—*Grid condenser*, 0.00025-mfd.
C_9—*Output condenser*, 200 volts, 4-mfd.
L_6—*Output choke*, 60 henries.
VT_1, VT_2—226 type *a.c. tubes.*
VT_3—227 type *a.c. tube.*
VT_4—171 type *tube.*
Three standard *four-prong sockets.*
One *five-prong socket.*
Binding posts.

C bias for the tubes is obtained from resistances R_1 and R_5.

The 227 type detector tube requires about 30 seconds to heat up and begin functioning and therefore about this length of time must lapse between the time the power is turned on and the set begins to operate. The receiver must, of course, be carefully neutralized.

No. 190 RADIO BROADCAST Laboratory Information Sheet **May. 1928**



A revised arrangement of the well-known "Universal" circuit which provides for the use of a.c. tubes. It is fully described on Laboratory Sheet No. 189

No. 191 RADIO BROADCAST Laboratory Information Sheet **May, 1928**

Index

August, 1927, to May, 1928

	Sheet Number	Month
Acoustics	166	February
A Battery Chargers	120	August
Audio Amplifier:		
A.C. Operated	148,149	December
Frequency and load characteristic	118	August
General considerations	165	February
Resistance-Coupled	131,132	October
Transformer Ratio, Effect of	179	April
Capacity, The Unit of	138	November
Carrier Telephony	136	October
Chargers, A Battery	120	August
Choke Coils, Radio-Frequency	119	August
Condenser Reactance	126,127	September
Constant Frequency Stations	153	January
Coupled Circuits	135	October
Ear, Characteristics of the	168	February
Exponential Horn, The	178	April
Fading	160	January
Filter Choke Coils	175	March
Filter Condensers	182	April
Gain, R. F. Amplifiers	147	December
Glow Tubes:		
How they function	129	October
Why they are used	173	March
Grid Bias		
Calculating Its Value	187	May
Why It Is Used	174	March
Hertz Antenna	121	September
Honeycomb Coils, Data on	130	October
Inductive Reactance	139,140	November
Loud Speakers:		
Exponential Type	134	October
General Considerations	145	December
Modulated Oscillator	164	February
Morse Code	125	September
Oscillation Control	150	December
Output Devices	113	August
Overloading, Effect on Tube	185	May
Power Supply Devices:		
Calculation of various voltages	142	November
Care of	133	October
Characteristics at various voltages	146	December
Desirable Characteristics	128	September
Transformer Voltages, Effect of	180	April

No. 192 RADIO BROADCAST Laboratory Information Sheet **May, 1928**

Index (*Continued*)

August, 1927, to May, 1928

	Sheet Number	Month
Radio-Frequency Choke Coils	119	August
R. F. vs. A. F. Amplification	181	April
Receivers, Testing of	122	September
" "	163	February
Resonant Circuits	167	February
Roberts Reflex, The	158,159	January
Selectivity	170	March
Sensitivity	170	March
Single-Control Receiver, Boosting Sensitivity of	151	December
Solenoid Coil Data	143	November
Speech:		
Articulation	177	April
Sources of Information on	152	December
Standard Frequency Stations	153	January
Static	116	August
Super-heterodyne, The	117	August
Transmission Unit, The	114	August
	145	December
Tubes:		
Alternating-Current Types	141	November
Comparison of 112 and 171	171	March
Comparison of 112, 171, and 210	161,162	February
Effect of plate circuit on grid circuit	176	March
Parallel Operation	137	November
171	123,124	September
112-A	154	January
171-A	154	January
222	169	March
280 and 281	183	April
250	186	May
Tuning, Effect of Distributed Capacity on	184	April
"Universal" Receiver, A. C. Operation of	189,190	May
Wavelength-Frequency Conversion	156,157	January
Wavemeter, A Simple	172	March
Wave Traps	155	January
" "	115	August

PRESS, WEATHER, AND TIME SIGNALS

THE list below has just been released by the Navy Department, radio service, to RADID BRDADCAST. It includes the press, weather hydrographic, and time signals transmitted by United States Naval Stations throughout the world. This list supersedes that appearing on page 514 of this magazine for March, 1927. The material in columns three and four below is of especial interest. The abbreviations employed and their meaning follows: "i.c.w." interrupted continuous wave; "c.w.," continuous wave; "a.c.w.," raw a.c. These transmissions are of vital importance to all marine and shore station operators. Other readers who are interested in listening to these signals should employ a simple regenerative circuit with a long antenna. A satisfactory receiver for this purpose was described on RADIO BROADCAST Laboratory Information Sheet No. 19, August 1926. Also, the article, "A Portable Long-Wave Receiver," page 166, RADID BRDADCAST, July 1927, describes a receiver especially designed for long-wave reception.

TIME (GREENWICH CIVIL)	STATIDN	CALL SIGN	FREQUENCY IN KC/S AND TYPE OF EMISSION	MATERIAL BROADCAST
0000	Brownsville, Tex.	NAY	132 i. c. w.	*Weather.*
0045	San Juan, P. R.	NAU	48 c.w.	*Weather* (1 July to 15 November).
0100	Norfolk, Va. Puget Sound, Wash.	NAM NPC	122 i.c.w. 118 c.w.	*Weather* *Weather.*
0115	Arlington, Va.	NAA	4015 i.c.w.	*Aviation weather and upper air reparts.*
0130	Eureka, Calif. Norfolk, Va.	NPW NAM	104 i.c.w. 122 i.c.w.	*Weather, hydrographic.* *Weather.*
0200	Cavite, P. I. Guantanamo Bay, Cuba. San Juan, P. R.	NPO NAW NAU	56 c.w. & 112 i.c.w. 118 i.c.w. 106 i.c.w.	*Press.* *Weather* (1 June to 15 November). *Weather* (1 July to 15 November).
0255 to 0300	Arlington, Va. Annapolis, Md. Cavite, P. I.	NAA NSS NPO	112 i.c.w. 690 i.c.w. 4015 i.c.w. 8030 i.c.w. 12045 i.c.w. 17.6 c.w. 56 c.w. 112 i.c.w.	 *Time Signals.* *Time Signals.* *Time Signals.*
0300	Arlington, Va. Cavite, P. I. Key West, Fla. Puget Sound, Wash.	NAA NPO NAR NPC	36 c.w. 112 i.c.w. 56 c.w. 112 i.c.w. 102 i.c.w. 118 c.w.	*Marine Weather followed by Navigational Warnings and ice reports* (in season). *Weather, hydrographic.* *Weather, hydragraphic.* *Hydragraphic.*
0305	Navy Yard, Wash. D. C.	NAA	690 voice	*Weather.*
0330	San Francisco, Calif. Tutuila, Samoa	NPG NPU	42.8 c.w. 108 i.c.w. 66 c.w.	*Weather, hydragraphic.* *Hydragraphic.*
0355 to 0400	Balboa, C. Z. Colon, C. Z.	NBA NAX	46 c.w. 132 i.c.w.	*Time Signals.* *Time Signals.*
0400	Arlington, Va. Great Lakes, Ill. Puget Sound, Wash. San Juan, P. R.	NAA NAJ NPC NAU	4015 i.c.w. 132 i.c.w. 118 c.w. 48 c.w.	*Weather broadcast to Europe.* *Weather, hydrographic.* *Weather.* *Weather.*
0430	Astoria, Oreg. San Diego, Calif.	NPE NPL	112 i.c.w. 102 i.c.w.	*Hydrographic.* *Weather.*
0500	Brownsville, Tex.	NAY	132 i.c.w.	*Weather.*
0555 to 0600	San Francisco, Calif.	NPG	42.8 c.w. 62 c.w. 108 i.c.w.	*Time Signals.*
0600	San Francisco, Calif.	NPG	108 i.c.w.	*Weather, hydrographic.*
0630	Honolulu, T. H.	NPM	54 a.c.w.	*Weather, hydragraphic.*
0700	Annapolis, Md. Arlington, Va.	NSS NAA	17.6 c.w. 112 i.c.w.	*Press.* *Press.*
0730	Tutuila, Samoa	NPU	66 c.w.	*Hydrographic.*
1000	Balboa, C. Z. Balboa, C. Z. Colon, C. Z. San Diego, Calif.	NBA NBA NAX NPL	46 c.w. 118 c.w. 132 i.c.w. 30.6 c.w.	*Press and hydrographic.* *Press.* *Hydragraphic.* *Press.*
1300	Puget Sound, Wash.	NPC	118 c.w.	*Weather.*
1315	Arlington, Va.	NAA	4015 i.c.w. 8030 i.c.w. 12045 i.c.w.	*Aviation weather and upper air reports.*
1330	Norfolk, Va.	NAM	122 i.c.w.	*Weather.*
1355 to 1400	Cavite, P. I.	NPO	56 c.w. 112 i.c.w.	*Time Signals.*
1400	Cavite, P. I.	NPO	56 c.w. 112 i.c.w.	*Weather, hydragraphic.*
1500	Arlington, Va.	NAA	112 i.c.w. 16060 i.c.w.	*Marine weather fallowed by ice reparts* (in season).
1505	Arlington, Va.	NAA	690 voice	*Weather.*

PRESS, WEATHER, AND TIME SIGNALS

(*Continued*)

Time (Greenwich Civil)	Station	Call Sign	Frequency in kc/s and Type of Emission	Material Broadcast
1530	New York, N. Y.	NAH	108 i.c.w.	*Weather, hydragraphic.*
	Charleston, S. C.	NAO	122 i.c.w.	*Weather, hydragraphic.*
1545	Philadelphia, Pa.	NAI	104 i.c.w.	*Weather, hydragraphic.*
	Great Lakes, Ill.	NAJ	132 i.c.w.	*Weather, hydragraphic.*
	Norfolk, Va.	NAM	122 i.c.w.	*Weather, hydragraphic.*
1600	Boston, Mass.	NAD	102 i.c.w.	*Weather, hydragraphic.*
	Newport, R. I.	NAF	118 i.c.w.	*Weather, hydragraphic.*
	Arlington, Va.	NAA	12045 i.c.w.	*Weather broadcast to Europe.*
	New Orleans, La.	NAT	106 c.w.	*Weather, hydragraphic.*
	San Juan, P. R.	NAU	48 c.w.	*Weather.*
	Savannah, Ga.	NEV	132 i.c.w.	*Weather.*
1630	Jupiter, Fla.	NAQ	132 i.c.w.	*Weather.*
	San Diego, Calif.	NPL	102 i.c.w.	*Weather.*
	St. Augustine, Fla.	NAP	128 spark	*Weather.*
1645	Pensacola, Fla.	NAS	112 i.c.w.	*Weather.*
1655 to 1700	Arlington, Va.	NAA	112 i.c.w. 690 i.c.w. 4015 i.c.w. 8030 i.c.w. 12045 i.c.w.	*Time Signals.*
	Annapolis, Md.	NSS	17.6 c.w.	*Time Signals.*
	Great Lakes, Ill.	NAJ	132 i.c.w.	*Time Signals.*
	Key West, Fla.	NAR	102 i.c.w.	*Time Signals.*
	New Orleans, La.	NAT	106 c.w.	*Time Signals.*
	San Diego, Calif.	NPL	30.6 c.w. 102 i.c.w.	*Time Signals.*
1700	Arlington, Va.	NAA	112 i.c.w.	*Navigational warnings.*
	Brownsville, Tex.	NAY	132 i.c.w.	*Weather.*
	Eureka, Calif.	NPW	104 i.c.w.	*Weather, hydragraphic.*
	Key West, Fla.	NAR	102 i.c.w.	*Weather, hydragraphic.*
	Puget Sound, Wash.	NPC	118 c.w.	*Weather, hydragraphic.*
	San Francisco, Calif.	NPG	42.8 c.w.	*Weather, hydragraphic.*
1755 to 1800	Balboa, C. Z.	NBA	46 c.w.	*Time Signals.*
	Colon, C. Z.	NAX	132 spark	*Time Signals.*
1800	Balboa, C. Z.	NBA	46 c.w.	*Hydragraphic.*
1830	Honolulu, T. H.	NPM	54 a.c.w.	*Weather, hydragraphic.*
1930	Tutuila, Samoa	NPU	66 c.w.	*Hydragraphic.*
1955 to 2000	Astoria, Oreg.	NPE	112 i.c.w.	*Time Signals.*
	Eureka, Calif.	NPW	104 i.c.w.	*Time Signals.*
	San Francisco, Calif.	NPG	42.8 c.w. 62 c.w. 108 c.w.	*Time Signals.*
2045	Arlington, Va.	NAA	690 voice	*Weather.*
2100	Norfolk, Va.	NAM	122 i.c.w.	*Weather, hydragraphic.*
	Puget Sound, Wash.	NPC	118 c.w.	*Weather, hydragraphic.*
2130	Astoria, Oreg.	NPE	112 i.c.w.	*Hydrographic.*
2200	Boston, Mass.	NAD	102 i.c.w.	*Weather, hydragraphic.*
	Newport, R. I.	NAF	118 i.c.w.	*Weather, hydragraphic.*
	New York, N. Y.	NAH	108 i.c.w.	*Weather, hydragraphic.*
	Phila, Pa.	NAI	104 i.c.w.	*Weather, hydragraphic.*
	Annapolis, Md.	NSS	17.6 c.w.	*Ice reports* (in season).
	Eureka, Calif.	NPW	104 i.c.w.	*Weather, hydragraphic.*
	Great Lakes, Ill.	NAJ	132 i.c.w.	*Hydragraphic.*
	New Orleans, La.	NAT	106 c.w.	*Weather, hydragraphic.*
	San Diego, Calif.	NPL	102 i.c.w.	*Weather.*
2230	Honolulu, T. H.	NPM	54 a.c.w.	*Weather, hydragraphic.*
2300	Charleston, S. C.	NAO	122 i.c.w.	*Weather, hydragraphic.*
	Jupiter, Fla.	NAQ	132 a.c.w.	*Weather.*
	Pensacola, Fla.	NAS	112 i.c.w.	*Weather.*
	Savannah, Ga.	NEV	132 i.c.w.	*Weather.*
2330	Tutuila, Samoa	NPU	66 c.w.	*Hydrographic.*
2355 to 2400	Honolulu, T. H.	NPM	26. i.c.w. 106 i.c.w.	*Time signals.*

A TIME CONVERSION TABLE

Greenwich Mean Time was adopted by the recent International Radio Telegraph Convention in Washington for use in the Convention and regulations drawn up by it. Greenwich Civil Time is used in the Navy for navigation and that time is employed in naval almanacs. The conversion table below indicates the relation between G.C.T., G.M.T., and 75th Meridian Time. The latter is "Eastern Standard" Time and those living in other time belts can easily calculate the time to listen for these transmissions in their own locality.

G.C.T. (*Hours*)	G.M.T. (*Hours*)	75th Meridian
0	12	7.00 p.m.
6	18	1.00 p.m.
12	0	7.00 p.m.
14	2	9.00 p.m.
18	6	1.00 p.m.
22	10	5.00 p.m.
24	12	7.00 p.m.

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on page 57. Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. RADIALL COMPANY.

2. HARD RUBBER PANELS—Characteristics and properties of hard rubber as used in radio, with suggestions on how to "work" it. B. F. GOODRICH RUBBER COMPANY.

3. TRANSFORMERS—A booklet giving data on input and output transformers. PACENT ELECTRIC COMPANY.

5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.

7. TRANSFORMER AND CHOKE-COUPLED AMPLIFICATION—Circuit diagrams and discussion. ALL-AMERICAN RADIO CORPORATION.

9. VOLUME CONTROL—A leaflet showing circuits for distortionless control of volume. CENTRAL RADIO LABORATORIES.

10. VARIABLE RESISTANCE—As used in various circuits. CENTRAL RADIO LABORATORIES.

11. RESISTANCE COUPLING—Resistors and their application to audio amplification, with circuit diagrams. DEJUR PRODUCTS COMPANY.

12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.

15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.

15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.

16. VARIABLE CONDENSERS—A description of the functions and characteristics of variable condensers with curves and specifications for their application to complete receivers. ALLEN D. CARDWELL MANUFACTURING COMPANY.

17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION.

20. AUDIO AMPLIFICATION—A booklet containing data on audio amplification together with hints for the constructor. ALL AMERICAN RADIO CORPORATION.

21. HIGH-FREQUENCY DRIVER AND SHORT-WAVE WAVEMETER—Constructional data and application. BURGESS BATTERY COMPANY.

46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.

47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.

48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.

49. BYPASS CONDENSERS—A description of the manufacture of bypass and filter condensers. LESLIE F. MUTER COMPANY.

50. AUDIO MANUAL—Fifty questions which are often asked regarding audio amplification, and their answers. AMERTRAN SALES COMPANY, INCORPORATED.

51. SHORT-WAVE RECEIVER—Constructional data on a receiver which, by the substitution of various coils, may be made to tune from a frequency of 16,660 kc. (18 meters) to 1999 kc. (150 meters). SILVER-MARSHALL, INCORPORATED.

52. AUDIO QUALITY—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. SILVER-MARSHALL, INCORPORATED.

56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.

57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.

59. RESISTANCE COUPLING—A booklet giving some general information on the subject of radio and the application of resistors to a circuit. DAVEN RADIO CORPORATION

62. RADIO-FREQUENCY AMPLIFICATION—Constructional details of a five-tube receiver using a special design of radio-frequency transformer. CAMFIELD RADIO MFG. COMPANY.

63. FIVE-TUBE RECEIVER—Constructional data on building a receiver. AERO PRODUCTS, INCORPORATED.

66. SUPER-HETERODYNE—Constructional details of a seven-tube set. G. C. EVANS COMPANY.

70. IMPROVING THE AUDIO AMPLIFIER—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. AMERICAN TRANSFORMER COMPANY.

72. PLATE SUPPLY SYSTEM—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. AMERTRAN SALES COMPANY.

80. FIVE-TUBE RECEIVER—Data are given for the construction of a five-tube tuned radio-frequency receiver. Complete instructions, list of parts, circuit diagram, and template are given. ALL-AMERICAN RADIO CORPORATION.

81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.

82. SIX-TUBE RECEIVER—A booklet containing photographs, instructions, and diagrams for building a six-tube shielded receiver. SILVER-MARSHALL, INCORPORATED.

83. SOCKET POWER DEVICE—A list of parts, diagrams, and templates for the construction and assembly of socket power devices. JEFFERSON ELECTRIC MANUFACTURING COMPANY.

84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.

85. FILTER—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. THE ABOX COMPANY.

86. SHORT-WAVE RECEIVER—A booklet containing data on a short-wave receiver as constructed for experimental purposes. THE ALLEN D. CARDWELL MANUFACTURING CORPORATION.

88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.

89. SHORT-WAVE TRANSMITTER—Data and blue prints are given on the construction of a short-wave transmitter, together with operating instructions, methods of keying, and other pertinent data. RADIO ENGINEERING LABORATORIES.

90. IMPEDANCE AMPLIFICATION—The theory and practice of a special type of dual-impedance audio amplification are given. ALDEN MANUFACTURING COMPANY.

93. B-SOCKET POWER—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. NATIONAL COMPANY, INCORPORATED.

94. POWER AMPLIFIER—Constructional data and wiring diagrams of a power amplifier combined with a B-supply unit are given. NATIONAL COMPANY, INCORPORATED.

100. A, B, AND C SOCKET-POWER SUPPLY—A booklet giving data on the construction and operation of a socket power supply using the new high-current rectifier tube. THE Q. R. S. MUSIC COMPANY.

101. USING CHOKES—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. SAMSON ELECTRIC COMPANY.

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.

23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.

26. DRY CELLS FOR TRANSMITTERS—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. BURGESS BATTERY COMPANY.

27. DRY-CELL BATTERY CAPACITIES FOR RADIO TRANSMITTERS—Characteristic curves and data on discharge tests. BURGESS BATTERY COMPANY.

28. B BATTERY LIFE—Battery life curves with general curves on tube characteristics. BURGESS BATTERY COMPANY.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

32. METERS FOR RADIO—A catalogue of meters used in radio, with diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

35. STORAGE BATTERY OPERATION—An illustrated booklet on the care and operation of the storage battery. GENERAL LEAD BATTERIES COMPANY.

36. CHARGING A AND B BATTERIES—Various ways of connecting up batteries for charging purposes. WESTINGHOUSE UNION BATTERY COMPANY.

37. WHY RADIO IS BETTER WITH BATTERY POWER—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.

53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.

69. VACUUM TUBES—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. RADIO CORPORATION OF AMERICA.

77. TUBES—A booklet for the beginner who is interested in vacuum tubes. A non-technical consideration of the various elements in the tube as well as their position in the receiver. CLEARTRON VACUUM TUBE COMPANY.

87. TUBE TESTER—A complete description of how to build and how to operate a tube tester. BURTON-ROGERS COMPANY.

91. VACUUM TUBES—A booklet giving the characteristics and uses of various types of tubes. This booklet may be obtained in English, Spanish, or Portuguese. DEFOREST RADIO COMPANY.

92. RESISTORS FOR A. C. OPERATED RECEIVERS—A booklet giving circuit suggestions for building a. c. operated receivers, together with a diagram of the circuit used with the new 400-milliampere rectifier tube. CARTER RADIO COMPANY.

102. RADIO POWER BULLETINS—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the BH or B rectifier tubes. RAYTHEON MANUFACTURING COMPANY.

103. A. C. TUBES—The design and operating characteristics of a new a. c. tube. Five circuit diagrams show how to convert well-known circuits. SOVEREIGN ELECTRIC & MANUFACTURING COMPANY.

41. BABY RADIO TRANSMITTER OF 9XH-9EK—Description and circuit diagrams of dry-cell operated transmitter. BURGESS BATTERY COMPANY.

42. ARCTIC RADIO EQUIPMENT—Description and circuit details of short-wave receiver and transmitter used in Arctic exploration. BURGESS BATTERY COMPANY.

58. HOW TO SELECT A RECEIVER—A commonsense booklet describing what a radio set is, and what you should expect from it, in language that any one can understand. DAY-FAN ELECTRIC COMPANY.

67. WEATHER FOR RADIO—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. TAYLOR INSTRUMENT COMPANIES.

(*Continued on page 55*)

73. Radio Simplified—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. Crosley Radio Corporation.

76. Radio Instruments—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. Jewell Electrical Instrument Company.

78. Electrical Troubles—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. Burton Rogers Company.

95. Resistance Data—Successive bulletins regarding the use of resistors in various parts of the radio circuit. International Resistance Company.

96. Vacuum Tube Testing—A booklet giving pertinent data on how to test vacuum tubes with special reference to a tube testing unit. Jewell Electrical Instrument Company.

98. Copper Shielding—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. The Copper and Brass Research Association.

99. Radio Convenience Outlets—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set. Yaxley Manufacturing Company.

105. Coils—Excellent data on a radio-frequency coil with constructional information on six broadcast receivers, two short-wave receivers, and several transmitting circuits. Aero Products Company.

106. Audio Transformer—Data on a high-quality audio transformer with circuits for use. Also useful data on detector and amplifier tubes. Sangamo Electric Company.

107. Vacuum Tubes—Data on vacuum tubes with facts about each. Ken-Rad Company.

108. Vacuum Tubes—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. Arcturus Radio Company.

109. Receiver Construction—Constructional data on a six-tube receiver using restricted field coils. Bodine Electric Company.

110. Receiver Construction—Circuit diagram and constructional information for building a five-tube set using restricted field coils. Bodine Electric Company.

111. Storage Battery Care—Booklet describing the care and operation of the storage battery in the home. Marko Storage Battery Company.

112. Heavy-Duty Resistors—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. Ward Leonard Electric Company.

113. Cone Loud Speakers—Technical and practical information on electro-dynamic and permanent magnet type cone loud speakers. The Magnavox Company.

114. Tube Adapters—Concise information concerning simplified methods of including various power tubes in existing receivers. Alden Manufacturing Company.

115. What Set Shall I Build?—Descriptive matter, with illustrations, of fourteen popular receivers for the home constructor. Herbert H. Frost, Incorporated.

104. Oscillation Control with the "Phasatrol"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. Electrad, Incorporated.

116. Using a B Power Unit—A comprehensive booklet detailing the use of a B power unit. Tables of voltages—both B and C—are shown. There is a chapter on trouble-shooting. Modern Electric Mfg. Co.

117. Best Results From Radio Tubes—The chapters are entitled: "Radio Tubes," "Power Tubes," "Super Detector Tubes," "A. C. Tubes," "Rectifier Tubes," and "Installation." Gold Seal Electrical Co.

118. Radio Instruments, Circular "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. Weston Electrical Instrument Corporation.

119. The New Loftin White Circuit—A twenty-four page booklet explaining the principles and application of this popular circuit. Consolidated Radio Corporation.

120. The Research Worker—A monthly bulletin of interest to the home constructor. A typical feature article describes the construction of a special audio amplifier—Aerovox Wireless Corporation.

121. Filter Condensers—Some practical points on the manufacture and use of filter condensers. The difference between inductive and non-inductive condensers. Polymet Mfg. Corp.

122. Radio Tubes—Specifications and operating characteristics of vacuum tubes. Twenty-four pages. E. T. Cunningham, Inc.

123. B Supply Devices—Circuit diagrams, characteristics, and list of parts for nationally known power supply units. Electrad, Inc.

124. Power Amplifier and B Supply—A booklet giving several circuit arrangements and constructional information and a combined B supply and push-pull audio amplifier, the latter using 210 type tubes. Thordarson Electric Mfg. Co.

125. A. C. Tube Operation—A small but complete booklet describing a method of filament supply for a.c. tubes. Thordarson Electric Mfg. Co.

126. Micrometric Resistance—How to use resistances for: Sensitivity control; oscillation control; volume control; regeneration control; tone control; detector plate voltage control; resistance and impedance coupling; loud speaker control, etc. American Mechanical Laboratories.

Book Reviews

Radio Theory and Operating. By Mary Texanna Loomis. Chapters, 44. Pages, 886. Illustrations 632. Loomis Publishing Company, Washington, D. C. Price, $3.50.

"RADIO Theory and Operating" is one of the most comprehensive volumes so far published in its field, covering not only radio theory and circuits but also the necessary electrical engineering required in the operation of radio telegraph and radio telephone transmitters and receivers.

The book is obviously a product of most extensive and painstaking research and reading, and familiarity with the work of the best authorities on radio subjects. It is now issued, recently revised, in its third edition.

There are two possible treatments of comprehensive works on radio subjects. A book may be designed to appeal to the radio enthusiast who desires to understand thoroughly the theory and operation of radio. It may also be planned for the professional radio man who studies the subject as a member of a class conducted by an expert teacher. Miss Loomis's book is decidedly in the latter classification. Her treatment of the subject is in a matter of fact and unromantic style. This is not written in the spirit of condemnation, but merely to define the author's point of view.

The work is divided into four parts. The first, of twenty-five chapters, discusses the principles of transmitting. There are seventeen chapters dealing with the principles of electricity and magnetism, generators, condensers, transformers, and the essential parts of the radio transmitter before we come to Chapter XVIII, dealing with oscillating currents. Thus the groundwork is thoroughly laid before radio circuit principles are considered. The second part deals with receiving circuits, in eleven chapters; the third, devoted to vacuum tubes and continuous waves, comprises six chapters; the fourth, entitled "The Practical Radio Operator," covers that subject with eight chapters.

To substantiate my point that the book is based more on reading and research than upon practical experience in the handling of radio equipment (not that the author is without extensive practical experience), this last section quotes liberally and thoroughly digests the Government regulations applying to radio, abbreviations used in practice, message forms, traffic regulations, and the forms used in practical ship-to-shore operating, all material obtainable by research and consultation of authorities. On the other hand, when the author deals with troubles which may be encountered in the operation of transmitters and receivers, that clearness and completeness which otherwise characterizes the book is somewhat lacking. For example, the operation of crystal control in broadcasting stations is disposed of in the following paragraph:

"When crystal control is used, too high a voltage must not be placed on the crystal, as this may break it. From 300 to 400 volts appears to be the limit that the crystal can stand. Crystals are a great help in keeping the oscillation frequency constant and, by eliminating wastes due to wild oscillations, the radiation is increased. However, the crystals are not imperishable. They need care and have to be replaced occasionally."

The same characteristic of treatment may be observed in the discussion of possible troubles with receiving sets:

"If upon sitting down to listen, on what appears to be a correctly wired receiving set, nothing is heard, aside from the possibility of an error in the circuit, this may be caused by something very simple. The trick is to find the simple cause. Perhaps the most common cause of this is a short-circuited fixed condenser, either shunted across the telephone circuit or the first amplifying transformer. This may be caused by the use of a hot soldering iron as a condenser composed of copper or tin foil and waxed paper, is not intended to withstand heat. Where fixed condensers are soldered into a circuit, this must be done very cautiously. Probably the next most important cause for silence in a receiving set is a poor contact between the prongs on the base of the tubes and the springs in the socket. Springs should press tightly against the prongs," etc., etc.,

Considering that the volume is entitled "Radio Theory and Operating" and not merely "Radio Theory," possibly a better balanced book would have been produced by more complete and systematic arrangement of possible troubles encountered in the operation of transmitting and receiving apparatus.

Another peculiarity of the book is the meticulous care observed in giving credit to independent inventors whose work antedated those generally given credit for radio's important inventions. Unquestionably this attitude arises out of the fact that Miss Loomis's father is Dr. Mahlon Loomis, who demonstrated radio transmission and reception in 1872, in Virginia. His pioneer work is not generally recognized. A patent was issued him on July 30, 1872, and his demonstrations, a matter of public record, establish his priority over Marconi. But history invariably credits the man who first puts over a new idea or system commercially, whether he is the first inventor or not.

Doctor Loomis bears the same position in radio that Dr. Samuel Langley holds in aeronautics. The Wright brothers are credited with the invention of the airplane because they were the first to demonstrate it to the general public so that, through their influence, it has won recognition as a practical device. Glenn H. Curtis, substituting a modern motor for the steam engine originally installed as motive power in 1897, made Langley's plane fly successfully. But even this vindication of Langley has not deprived the Wright brothers of their position as the acknowledged inventors of the airplane.

Miss Loomis's book is to be recommended particularly to commercial wireless telegraph operators. The chapters dealing with the care of storage batteries, the functioning and care of motor generators and power equipment, and the regulations applying to commercial practice are thorough and complete. An extensive series of questions at the back of the book are helpful in preparing for Government examinations. Standard ship and commercial installations are quite thoroughly dealt with. The volume is well indexed and well arranged.

—Edgar H. Felix.

Another Text for Operators

Practical Radio Telegraphy, by Arthur R. Nilson and J. L. Hornung, McGraw-Hill Book Co., Inc., 380 pages, $3.00.

THE preface to this book states that it is written for radio students preparing to become radio operators. Its scope is therefore marine radio telegraphy, and does not include broadcasting. At first it may seem that enough books have been written to aid aspiring young electricians to survive the terrors of the government license examination, but this book really does the job extraordinarily well; better, I believe, than any previous work on the subject. The art has changed, and most of the earlier treatments

BOOK REVIEWS

(Continued from page 56)

Practical Radio Telegraphy—Nilson and Hornung

are out of date. This fact, as well as the long experience of the authors in the training of radio operators, justifies the appearance of the present volume.

The treatment begins with the physical fundamentals of the art, the first seven chapters being devoted to such topics as magnetism, motors and armatures, and characteristics of alternating current circuits. The treatment is nowhere skimpy; in the chapter on armatures, for example, the elements of armature winding are fully described. Wherever physical principles are expressed the atomic theory is used. Occasionally the phraseology is a little dubious, as in the discussion of dielectric breakdown on page 107, where the authors tell us that "a ruptured insulator might be defined as a material in which the electrons have been extended beyond their limit, or, in other words, the electrons have been strained beyond the elastic limit of the atomic structure. . . ." A strained electron might tax the conceptual powers of greater intellects than those of average young men studying to become brass pounders on the high seas. But the explanations are in the main clear and scientific; the one which has been quoted is not a fair example.

Photographs and practical illustrations of apparatus have been secured from manufacturers and communication companies. Spark, vacuum tube, and arc transmitters for marine use, commercial receivers, and the radio compass, are thoroughly described. Questions at the end of each chapter may be used by the student to test his knowledge. Most of the chapters are written to the length of a normal assignment in a radio school. The printing is first-rate, with the exception of a comical error in the running head of Chapter XXI. The book includes an index. It is written for readers who lack preparation in elementary electricity, mathematics, and chemistry, gives them what they need of such prerequisites, carries them through the technique of radio marine telegraphy, and fills the need for a reference book for finished operators.

—Carl Dreher.

In sending the coupon below, make sure that your name and address are included and are plainly written.

USE THIS BOOKLET COUPON

Radio Broadcast Service Department
Radio Broadcast, *Garden City, N. Y.*
Please send me (at no expense) the following booklets indicated by numbers in the published list above:

....

....

....

....

....

....

Name..

Address..
(*Number*) (*Street*)

....
(*City*) (*State*)

ORDER BY NUMBER ONLY
This coupon must accompany every request. RB 5-28

DIRECT SELLING BY RADIO

Is It a Menace to the Retail Business Structure?

By Francis St. Austell

President, Iowa Radio Listeners' League

OUT in Iowa, the haunt of direct selling by radio, all arguments for and against "Direct Advertising" and "Indirect Advertising" have been abandoned in favor of a heated controversy on the subject of direct selling by radio. Advertising, direct and indirect, has in the case of some radio stations, given place to urgent, persistent, forceful and vociferous clamoring for orders for all kinds of commodities.

The three terms, indirect advertising, direct advertising and direct selling have been defined as follows: Indirect advertising is the type of publicity sent out by a great number of stations including those on the networks. It consists of the name of the advertiser who sponsors the entertainment, with a mention of products in a manner calculated to create good will and also help all who are concerned in the merchandising of those products. Direct advertising consists of the broadcasting of requests for orders, with or without price quotations sent out by a station which has sold time to an advertiser for the purpose of selling goods by radio. Direct selling consists of the solicitation of orders by a station which sells goods direct to the consumer for its own account and for its own profit.

The center of the controversy is quite naturally Iowa, because the principal direct selling stations are located in that state. The writer is not familiar with the situation in other states, but is certainly very familiar with the Iowa station which is probably unique or ought to be.

A half-hour period usually called the "Letter Basket" has just been brought to a close by the owner and operator of KFNF Shenandoah. This station was the first to adopt the plan of selling directly to consumers and is still the chief exponent of the art. During the period referred to, the public was begged to send orders for tires, dishes, peaches, coffee, Chinese baskets, pencils, fountain pens (guaranteed for life) suits, overcoats, paint, canned corn and nursery stock, not forgetting prunes. Before the advent of radio, the owner and operator of KFNF was in the seed and nursery business. The other lines have apparently been added since the issue of a license to broadcast.

KFNF, Shenandoah, is now self-announced as the "merchandise center of the middle west"—"the pioneer trading station" and somewhat vaguely as "the world's largest." In a few short years a business primarily devoted to seeds and nursery stock, with an annual turnover of probably about three hundred or four hundred thousand dollars, has grown with the aid of radio into a business with a volume of more than three million dollars.

The entertainment furnished by KFNF is not of a high class nature. It is what is called common music for common people or simply old-fashioned music for plain folk. While the response from the public to the efforts at entertainment is meager, the response to the talks broadcast from that station is enormous. These talks are really clever and deal with agriculture, horticulture, household hints and many other subjects. KFNF has a following which numbers many hundreds of thousands and every one of them will fight if his favorite station is criticized. There is probably no station in the country that has such a loyal following and some extra bitter opponents of direct selling say that no other station wants such a following. The opponents of direct selling are divided into two classes. One class wants direct selling stations to be put off the air entirely. The other would be content if direct selling were abolished and would demand nothing more.

Henry Field of KFNF, just plain "Henry" to his friends, has a magnetic personality which reaches out and grips his audience. His description of a cup of his famous coffee is tantalizing and his vivid picturization of a cooked slice of his wonderful ham just makes one's mouth water. His coats are the best ever heard of, his overalls are works of art, his tires make motoring a joy forever, his canned peaches bring to our table the sunshine of California. It is a bad day when his sales talks do not bring a few thousands of dollars to the merchandise center.

THE FINE ART OF RADIO SELLING

HENRY FIELD has developed salesmanship by radio into a very fine art—so fine an art in fact that many claim that if his example were followed by others fortunate enough to own a radio station, the whole retail business structure of the country might be endangered. The selling of merchandise by radio is so profitable that it is surprising to find so few radio stations engaged in the pastime.

Those who oppose direct selling as unfair competition ask: "If one broadcaster is allowed to use the greater part of his time on the air for the purpose of soliciting orders, why should not every broadcaster do it? Why should not every man be given the right to erect and operate a radio station, provided he expresses the willingness or desire to sell prunes, peaches, tires, overalls and other commodities?"

At present, the local dealer who has no broadcasting station is in an unfortunate position. He is open to attack, direct, indirect, by accusation and by innuendo. Not having a radio station from which to shout, he is naturally at a loss for a reply. He gets sore and thinks of all kinds of smart "come backs," but he has to remain silent.

It is not unusual to hear over the air remarks to the effect that "your local merchant would charge you at least twelve dollars—but by buying from this station, you get it for seven dollars." The purchaser by radio also has the extra and exquisite pleasure of hearing his name "read out." The price comparison, according to reports from dealers, is not always fair or absolutely correct, but who can contradict it?

KFNF sometimes issues statements to the effect that the station does not undersell competitors and claims "quality" as the keynote of its business policy. At another time, the station claims to have forced down prices on many commodities and to have saved the farmer vast sums of money. Whether or not they save money or get better quality the loyal followers of Henry send their cash to his station and demand that he be allowed to do as he likes with his radio station.

It has been stated that the direct selling stations of Iowa can produce five hundred thousand signatures to support their claims to popularity. This is no doubt a very low estimate. But it may be asked whether the popularity of a station is sufficient excuse for what many regard as the evils of direct selling. On this subject a correspondent remarks "popularity has nothing to do with

DIRECT RADIO SELLING

by Francis St. Austell

(*continued from page 58*)

it. Saloons were popular once, but where are they now?" Correspondence comes from all over the country, from Rhode Island to California, from Maine to New Mexico, and it is a very noteworthy fact that most letters from opponents of the principles of direct selling are on excellent paper and represent a highly educated class, while those from supporters of the direct seller are for the most part, extremely hard to read, are not noted for cleanliness and usually avoid reference to the real subject of debate. The popularity of KFNF is based on its talks, its gospel hymns, religious services and its old-fashioned music. The opponents of direct selling do not necessarily criticize these features, but the loyal followers of KFNF see in an attack on direct selling, a camouflaged attack on the gospel. They want Henry or "Henery" and resent any suggestion of criticism, even of the station presided over by their idol. The owner and operator of KFNF recently broadcast a statement to the effect that those who did not like his station were writing to the Federal Radio Commission, telling that body all about it. He also commented on the fact that these people were sending typewritten letters. The young lady who sorts my mail was discovered once making two piles of letters before opening them. One was a clean, neat pile, the other was quite different. When asked the reason for such a procedure, she remarked "The clean ones object to direct selling, the dirty letters support it." Quite simple, but also very significant. Of course their are some very clean and well written letters favoring direct selling but these are conspicuous in comparison.

WHERE DIRECT SELLING IS POPULAR

AT A convention in Des Moines, held last year, a speaker attacked the principles of direct selling, without mentioning any stations by name. Mr. Field of KFNF requested that barriers be let down and that the matter be discussed openly, as he said he was quite aware the remarks referred to him. The way followers of Shenandoah rallied to his support was an eye opener to many. Women, who would ordinarily dread the ordeal of a public appearance, spoke fearlessly and eloquently, facing with real determination a crowded convention hall. Farmers and their wives told of what Henry had done for them, and they left not the slightest doubt as to the popularity of Henry Field among his immediate followers. To his opponents, he represents probably the most unpopular station in the world. Popularity is not the right word. This man, Henry Field, arouses a feeling among his followers that is akin to worship. He is becoming a cult. The reasonable opponents of direct selling do not hesitate to give him credit for all the good things he has done. They fight with him on the points only of direct selling and the methods employed in merchandising.

All the foregoing remarks can be applied to other stations, of course, as far as merchandising is concerned; but the magnetic personality of Henry Field makes him stand alone, a national figure, a creation of radio, a leader of hundreds of thousands, almost a prophet, a Moses of the common people.

It would seem that the direct selling stations sometimes act as agents for manufacturers and merchants, while certain commodities are bought outright and sold by the station which is in reality a mail order house, with a catalog and also the additional advantage of having a radio station from which to broadcast bargains. All

DIRECT RADIO SELLING

by Francis St. Austell

(*continued from page 59*)

goods are sold with a money back guarantee. Even the hams can be cooked, partly consumed and the remainder sent back if not satisfactory.

As an indication of the volume of business done figures recently broadcast from one of the so-called "farm stations" are given here. They indicate sales since February, 1927.

55 carloads of tires—400,000 pounds of coffee—100,000 overalls and jackets, 30,000 work and dress shirts, 70,000 dress patterns of $3\frac{1}{2}$ yards each—10,000 ready made dresses—24 carloads of prunes—60,000 pairs of silk stockings—50,000 radio tubes—3000 suits and overcoats since October 1927; that represents only a part of the business of one radio station. To the writer, the figures do not appear in any way exaggerated.

Retail merchants are becoming alarmed, followers of the farm stations are elated. The so-called farm stations claim the support of farmers as a class. One farmer writes and states plainly that it is a damned lie to say that all farmers are in favor of direct selling. Another is equally positive that farmers are all for it.

That broadcasters themselves are not entirely united on the subject of direct selling is indicated by the following quotation from a letter addressed to the writer by the secretary of the Berry Seed Company, which owns and operates station KSO, Clarinda, Iowa, This station was engaged in the direct radio sale of seeds and kindred lines. The letter says, in part:

> "The question of direct selling or the quotation of prices over the radio is one that is receiving much discussion not only in Iowa but in many other sections of the United States. . . .We cannot help but come to the conclusion, after considering the matter from all angles, that it does give such firms an undue advantage over competitors who have no radio station or access to one over which their prices may be quoted. This might readily be termed an unfair advantage and perhaps for that reason alone should be eliminated. . . . To return to our former statement, we would welcome an order to desist from quoting prices. We welcome a mutual agreement that would eliminate it, and if neither of these occur, we shall perhaps cease anyhow."

An ardent supporter of direct selling principles was asked by the writer if he could produce one logical argument in favor of it, merely said: "The broadcaster was lucky and he found a gold mine in a radio station. There is no law against using a gold mine."

There is no law to prevent a man from being lucky enough to find and use a gold mine, but unfortunately, there is a law which prevents a lot of people from founding a broadcasting station. One station of the direct selling kind, according to its own report, annually sends out catalogues to the number of a million and a half. The follow-up to these catalogues consists of direct selling talks by radio. Catalogues from other firms must be followed up by mail. It looks a bit one-sided, doesn't it?

The Radio Commission announces that it has not been given the power to dictate to a broadcaster whether or not he should sell and puts the matter up to the public.

Let the public decide—as quickly as possible.

SM

New!

5-Prong S-M Plug-In Coils

Economy—Efficiency

For the popular "tube base" short wave receiver Silver-Marshall will have ready on June 1st, new types of moulded Bakelite coil forms and wound coils designed to fit any standard 5-prong tube socket, such as S-M 512. These forms have ample winding space for all short wave or broadcest band coils, and a tickler slot at the base. Their small size particularly adapts them to short wave sets to provide the smooth regeneration necessary to telephone or rebroadcast reception, and their cost is as low as their efficiency and flexibility is high. Type 130 blank forms can be had with smooth winding space 1½" in diameter and 1½" long, with tickler slot and pins at .50 each, or with threaded winding space (98 threads) if preferred. A variety of types wound for different purposes can be had at $1.25 each list. Type 512 socket which fits these coils is priced at 75c

Why pay $8.00 to $12.00 for a set of short wave coils when four 130 forms and a 512 socket costing $2.75 altogether, plus less than a pound of wire and an hour's fun will give you as pretty a little set of coils, tuning from 17 to over 200 meters, as you'd ever want to see.

The Famous S-M 240 Audio Transformer

At $6.00 S-M 240 Audio transformers, containing more actual material than competitive $8.00 transformers, give such fine performance that they are being increasingly chosen in preference to other makes. The Peridyne used them, the LC 28 Unipac was built around them, the Universal Tuners rely on 240's for the fine tone that has made them so popular. Radio Broadcast Laboratory has reported most favorably on them. Small, compact, rugged and above all possessed of the qualities that have made S-M leader in the audio field in two short years, they are your guarantee of fine tone quality in any set you buy or build. Price, 240 audio, 3:1 ratio, $6.00; 241 output, $5.00.

A B C and B Power Units to Fit in Your Set Cabinet

The new S-M "670" Reservoir Power Units are but 13" long, 3⅜" wide and 6½" high over the 280 rectifier tube they use. Both are housed in attractive brown crystalline steel cases, and have the features that made the older 652 and 656 Reservoir B's the most popular kits of their type. The Clough selective filter and a new voltage divider system provide unusually quietness and freedom from motorboating on any set of one to ten tubes. 670B supplies fixed voltages of 22½, 90, 135 and 180 to 200 volts, with a variable tap giving from 22½ to 90 volts. 670ABC supplies the same B power and A and C power to any AC tube set—1.5 volts, 2.25 and 5.0 volts A for up to seven tubes, with the necessary C bias for the tubes used obtained by suitable resistors in the set. 670B is priced at $35.50 wired, ready to use, or $33.00 in kit form, with cabinet, ready to assemble. 670ABC is priced at $38.50 wired, or $35.00 for the complete kit with all instructions.

New Unipacs for 250 Tubes

Two Unipacs taking full advantage of the new 250 type tube are ready, one a single stage light socket power amplifier and B supply, and the second a two stage amplifier for radio or phonograph. Each uses one UX-250 amplifier tube to furnish 4650 milliwatts of undistorted power output, which means just about the sweetest, fullest tone you've ever heard—just a shade better than you can get with the next best.

Both Unipacs are peers in their fields, operate from 105 to 120 volt 60 cycle alternating current, and deliver 450 volts B and 84 volts C to the self contained 250 tube which develops more undistorted power output than two 210's in push pull.

681-250 is the single stage model using one 250 tube, two 281 rectifiers and one 874 voltage regulator. Besides a stage of 250 amplification for any radio set, it also furnishes 45, 90 and 135 volts of B power. Price wired $98.25, or in kit form ready to assemble, $83.25. 682-250 is the single stage model with a 226 first stage tube added. It supplies two stages of power A. F. amplification—enough for dance hall volume using the output of a record pick-up or radio set detector tube. It gives 45, 90 and 135 volts of B and 1.5 and 2.25 volts of A for receiver operation. Price wired, $107.75, or as a kit, ready to assemble $92.75.

SILVER-MARSHALL, Inc. 838 West Jackson Blvd., Chicago, Illinois

SILVER-MARSHALL, Inc., 838 West Jackson Blvd., Chicago, Ill.

....I enclose 10c for which please send me full information on the S-M audio transformers, power supply units, unipacs, and the S-M receivers.
....I enclose 25c for instructions for building the S-M unipacs.
....I enclose 25c for instructions and blueprints for building the Shielded Grid Sixes.
....I enclose 25c for instructions and blueprints for building the S-M wave tuners.

Name ....

Address ....

RADIO BROADCAST

JUNE, 1928

WILLIS KINGSLEY WING, Editor

KEITH HENNEY, Director of the Laboratory

EDGAR H. FELIX, Contributing Editor

Vol. XIII. No. 2

CONTENTS

The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

AMONG OTHER THINGS. .

IT HAS not been possible to reply with a personal letter to each of our readers who filled out and returned the readers' questionnaire recently sent many of those who are regular subscribers. The desires and opinions of readers expressed have been very helpful. Many interesting conclusions are at once apparent. Our policy of giving complete information about the manufactured parts described in constructional articles is overwhelmingly approved. The type and form of the articles dealing with the construction of apparatus—such articles as those in this issue for example—are welcomed. The many special features and articles which distinguish RADIO BROADCAST from its contemporaries are especially praised.

SOME readers who have read elaborate statements of policy appearing in some of our contemporaries have asked us, in effect, if we were going to announce a changed policy, too. All we have to say about the editorial policy of RADIO BROADCAST has been said in this column in the May issue. This magazine is edited for the reader and what he finds in RADIO BROADCAST is information—lots of it, as interestingly, as completely, as accurately presented as we know how. This magazine will neither be full of inconsequential and slightly sensational articles about the marvelous potentialities of radio nor will it overflow with constructional articles on every possible subject having the apparent purpose of merely using the products of a selected group of radio manufacturers. Our policy of making each article complete in itself and not "continued on page 96" is still in force. The special sections which have so wide a following: the Laboratory Data Sheets, the March of Radio, Strays from the Laboratory, Our Readers' Suggest . . . , As the Broadcaster Sees It, the Service Department, are to be continued. With this issue, we introduce a new regular feature: "RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers" which present all essential data on various makes of sets now in use. Several other important new features are in the course of preparation.

EDGAR H. FELIX, contributing editor, attended the public hearings before the Radio Commission April 23 and 24. He appeared as an expert witness and presented the suggestions for the solution of the broadcasting problem which have attracted such wide attention in our editorial section, The March of Radio. Incidentally, we are told that Mr. Felix's May article "Will New Transmitting Methods Be the Remedy?" is accepted in Washington as the most clear and fair presentation of the difficulties and possibilities for solution of the present broadcast situation.

OUR July issue promises many interesting features. There is an excellent non-radiating short-wave receiver using a screen-grid tube, a searching analysis of the almost overwhelming obstacles to practical television, the description of a fine B supply and power amplifier using the 250 type tube, a practical set tester, and many other articles, selected because of their unusual interest.

—WILLIS KINGSLEY WING.

DOUBLEDAY, DORAN & COMPANY, INC., Garden City, New York

MAGAZINES

COUNTRY LIFE
WORLD'S WORK
GARDEN & HOME BUILDER
RADIO BROADCAST
SHORT STORIES
EDUCATIONAL REVIEW
LE PETIT JOURNAL
EL ECO
FRONTIER STORIES
WEST
THE AMERICAN SKETCH

BOOK SHOPS (Books of all Publishers)

NEW YORK: LORD & TAYLOR; JAMES MCCREERY & COMPANY; PENNSYLVANIA TERMINAL AND 166 WEST 32ND ST.; 848 MADISON AVE. AND 51 EAST 44TH STREET; 420 AND 526 AND 819 LEXINGTON AVENUE; GRAND CENTRAL TERMINAL AND 38 WALL STREET
CHICAGO: 75 EAST ADAMS STREET
ST. LOUIS: 223 N. 8TH ST. AND 4914 MARYLAND AVE.
KANSAS CITY: 920 GRAND AVE. AND 206 WEST 47TH ST.
CLEVELAND: HIGBEE COMPANY
SPRINGFIELD, MASS: MEEKINS, PACKARD & WHEAT

OFFICES

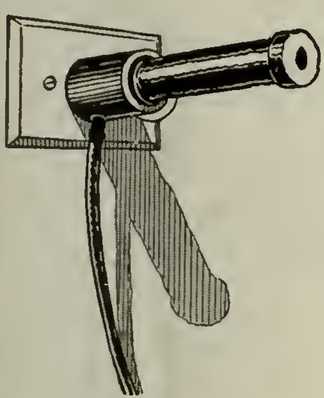
GARDEN CITY, N. Y.
NEW YORK: 244 MADISON AVENUE
BOSTON: PARK SQUARE BUILDING
CHICAGO: PEOPLES GAS BUILDING
SANTA BARBARA, CAL.
LONDON: WM. HEINEMANN, LTD.
TORONTO: OXFORD UNIVERSITY PRESS

OFFICERS

F. N. DOUBLEDAY, *Chairman of the Board*
NELSON DOUBLEDAY, *President*
GEORGE H. DORAN, *Vice-President*
S. A. EVERITT, *Vice-President*
RUSSELL DOUBLEDAY, *Secretary*
JOHN J. HESSIAN, *Treasurer*
LILLIAN A. COMSTOCK, *Ass't Secretary*
L. J. MCNAUGHTON, *Ass't Treasurer*

TERMS: $4.00 a year; single copies 35 cents.

Protect your A-C tubes from high line *voltages*
with
Ward Leonard Vitrohm Resistors and Rheostats



Radio receivers, made for complete operation from the power lines, are designed, usually, to operate at a fixed line voltage. Where the line voltage exceeds the arbitrary value assumed by the set manufacturer, damage to the tubes may result unless means are used to reduce the line voltage to the value at which the set is designed to operate.

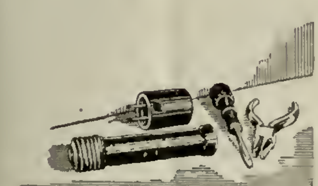
Two methods are used, ordinarily, to correct for excessive line voltages; a resistor or rheostat placed in series with the input to the power unit of the receiver. The resistance value and current carrying capacity of these units is determined by the receiver primary current and the maximum potential drop required.

Vitrohm Resistors, fitted with Edison medium screw bases, are the most convenient units to use where fixed resistance is desired. These resistors screw into a series tap which is in turn plugged into the convenience outlet or socket. They are priced at $2.00 each and are available in the resistances listed below:

Catalog Number	*Resistance In Ohms*	*Catalog Number*	*Resistance In Ohms*
507-96	2.5	507-97	15
507-39	3.5	507-98	22
507-41	5	507-99	31
507-43	7	507-100	45
507-44	10	507-101	62
507-45	12.5		

Vitrohm 4-inch, 11 step, Rheostats are used where adjustment of voltage is desirable or necessary. Mounting may be either front or back of panel. The price is $5.50 each.

Catalog Number	*Maximum Resistance In Ohms*
507-83	12.5
507-59	20
507-63	50

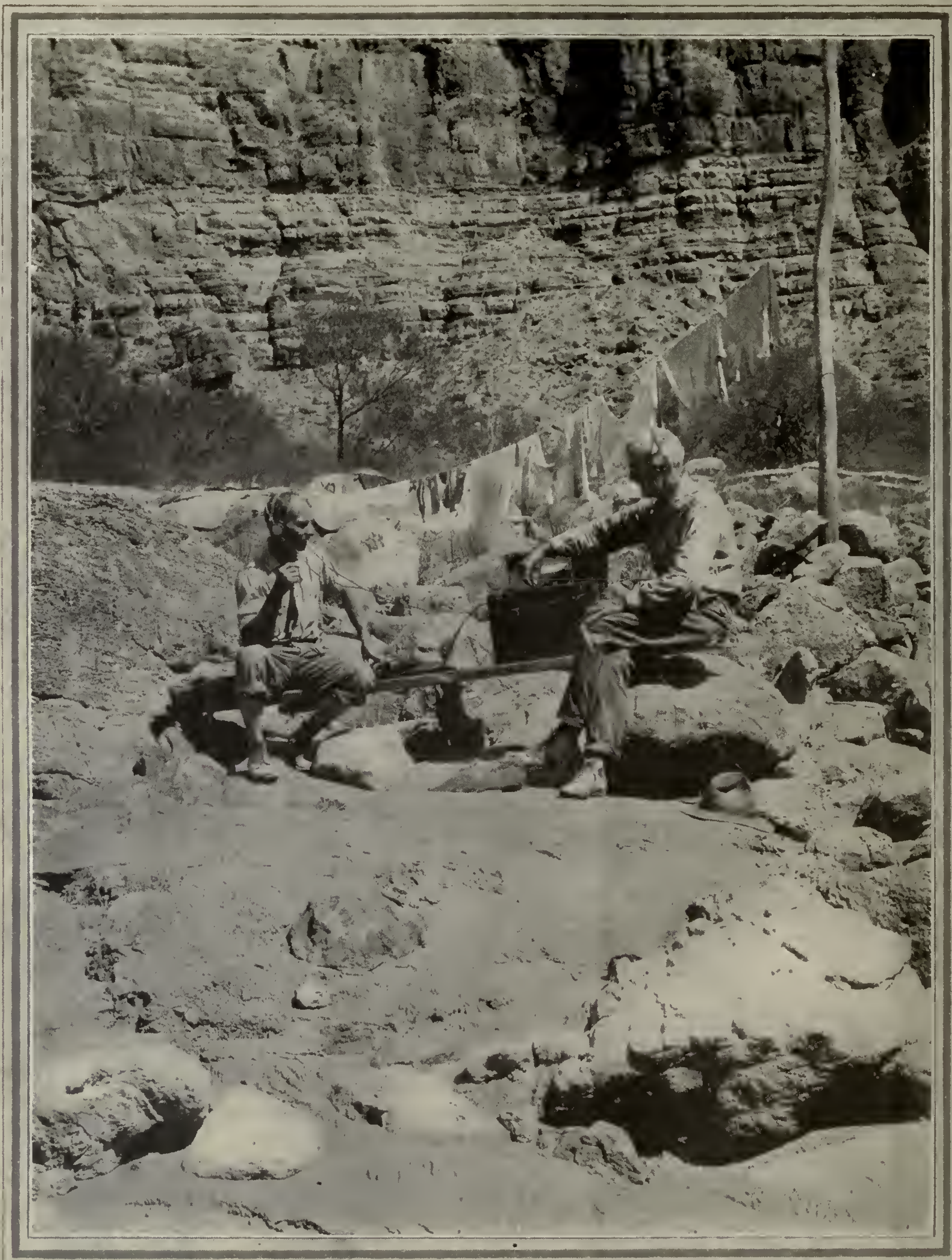


Your dealer stocks Vitrohm Resistors and Rheostats, or can get them for you. Circular 512 describes methods of line voltage control and shows complete diagrams of circuit connections. It will be sent to you promptly upon request without charge.

WARD LEONARD ELECTRIC CO.

MOUNT VERNON, N.Y.

RESISTOR SPECIALISTS FOR MORE THAN THIRTY-SIX YEARS



In the Grand Canyon of the Colorado

A PORTABLE radio receiver in use in the Grand Canyon in 1923. A special receiver was built for the expedition by the Bureau of Standards which was carried on a geological survey of the Canyon under the auspices of the United States Geological Survey. This illustration is from a photograph by Lewis R. Freeman, of the Explorers' Club, New York, who was a member of the expedition. Mr. Freeman explains that at the time the expedition was undertaken, there was some doubt as to whether radio reception would be possible in the Canyon. It was conclusively demonstrated that excellent reception was possible. The receiver performed as well at depths of 500 feet as at 5000, Mr. Freeman says. The antenna in the illustration also, it seems, served the party as a clothesline.

How Chain Broadcasting Is Accomplished

By C. E. Dean

American Telephone and Telegraph Company

CHAIN broadcasting is known to radio listeners as a means whereby a radio program may be transmitted by several or even dozens of radio stations. Regular networks furnish entertainment every day, and on important occasions great extensions are made so that practically the entire United States is covered. The estimated audiences at such times include one fourth to one third of the entire population of the country. More people have thus listened to the voice of one person than ever before in history.

The apparatus and methods whereby such important and remarkable results are accomplished are, therefore, interesting subjects to the radio fan. His knowledge of vacuum tubes, audio-frequency amplifiers, and electrical principles will enable him to appreciate various interesting points in the equipment and operation of the wire lines used in chain broadcasting.

In addition to the long lines connecting to radio stations in distant cities, there are many shorter lines transmitting programs, such as from studios centrally located in large cities to the powerful radio broadcasting apparatus out beyond the suburbs. Similar circuits are used to broadcast sporting events, banquets, and other occurrences outside the studio, thus greatly extending the range of program features.

It is one of the duties of telephone engineers and operating men to plan and supervise both the short and long lines which carry radio programs. These connections differ in various respects from regular local and long distance telephone lines, and have, therefore, been given a special name, "program circuits." One difference is that ordinary telephone circuits transmit the voice in both directions (on long circuits "two-way" amplifiers are therefore necessary), but in program circuits it is necessary to transmit only in one direction, that is, from the pick-up microphone to the one or more radio transmitting stations. "One-way" repeaters are therefore sufficient. In the drawing on page 66 arrows indicate the direction of transmission along each program circuit which was used on January 4th, 1928, the date of the first Dodge Brothers program. The regular route of the voice of Will Rogers, acting as master of ceremonies at Los Angeles, may be followed by way of San Francisco and Denver to Chicago and the East. Also an additional circuit for use in case of emergency is seen passing through southern New Mexico, Dallas, and St. Louis to Chicago.

THE CHAIN BROADCASTING CONTROL ROOM IN CHICAGO

Similar control rooms are located in Boston, Cincinnati, Detroit, St. Louis, Atlanta, San Francisco, and New York, each in charge of a "transmission supervisor." Repeaters, oscillators, equalizers, transmission measuring devices, and other apparatus necessary in the exacting work of transmitting the programs are shown in the illustration. Cone loud speakers are mounted in the protecting frames at the left. During operation, one cone is connected to the Red network, another to the Blue, a third to the Purple; the fourth is a spare.

MEETING THE TRANSMISSION REQUIREMENTS

ANOTHER important difference between ordinary telephone circuits and program circuits is in the width of the frequency band transmitted. In a telephone conversation, clear, intelligible speech is desired, and it has been found that this can be obtained if frequencies from about 300 cycles per second to about 2000 cycles per second are transmitted, although modern telephone circuits are engineered to carry a somewhat wider frequency range. However, with program circuits, not only satisfactory intelligibility is desired, but also a very high degree of naturalness and faithfulness in the transmission of music and speech when reproduced through loud speakers. To meet these requirements, a much wider band of frequencies is necessary. In the present art it is generally considered desirable to transmit a range of frequencies from about 100 cycles per second to about 5000 cycles per second, and to do this with approximately uniform efficiency. In this way the low, medium and high pitch ranges of music and other program material are transmitted with a considerable degree of faithfulness.

In addition to the wider frequency-range requirements, program circuits are called upon to transmit greater volume variations than ordinary telephone circuits. For example, the music of a symphony orchestra will vary from a very loud intensity, when many instruments are sounding, to a very faint intensity at other times.

What Radio Owes to Chain Broadcasting

THE Washington air, in and near the halls of Congress, has been full of pointed and often unpleasant comments about chain broadcasting during the recent weeks when the last radio bill was under consideration. Aside from the political aspects which so fascinate our legislators, it can be said without fear or favor that chain broadcasting is responsible almost entirely for the growth of high-grade programs in this country. Chain broadcasting has partially solved the old question: "Who is to pay for broadcasting?" As the use of the wire network, linking stations, has increased, so has the radio audience, and with it the time, money, and effort expended on programs. This article explains some of the technical aspects of the accomplishment, much of which appears for the first time.

—The Editor.

At all times extraneous noise on the circuit must be slight in comparison with the volume of the music. The critical times are during the faint portions of the program, and to transmit these satisfactorily, a very quiet circuit is obviously necessary.

The large variations in the volume of orchestral music (which are of the order of 50 TU, an energy ratio of 100,000) are greater than radio stations can transmit without overloading on the loud signals and losing the faint portions in local noise, static, etc., at the receiver. So at the microphone amplifier one of the broadcast station control operators manipulates the amplification control so as to reduce these variations, cutting down somewhat the loud portions and bringing up somewhat the faint portions, taking care to preserve as nearly as possible the naturalness of the music. The program circuits, i. e., wire lines are quiet enough to be able to more than handle all the volume variation which the broadcasting radio stations desire to transmit.

Besides the requirements just considered, the program circuits must of course function harmoniously with the other circuits of the telephone plant, so that program transmission will not be overheard on the ordinary circuits, nor vice versa.

For short connections in cities and at other places, circuits in cable are usually employed. The attenuation, the loss, introduced by a seven-mile length of 19-gauge cable pair (consisting of No. 19 B & S copper wire), with no loading coils or other apparatus connected, increases considerably with increase of frequency. One TU of loss means a reduction of power to $79\frac{1}{2}$ per cent. of its original value, two transmission units means a further reduction to $79\frac{1}{2}$ per cent. of what is left, or to $.795 \times .795 = .63 = 63$ per cent. of the original amount.

Three TU is a power ratio of 50 per cent., four is 40 per cent., and five TU 32 per cent. Twenty TU is a power reduction to 0.01 or 1 per cent. of its original value, as shown by the bottom line of the chart. (TU are also used to express the amount of amplification, or "gain," of an amplifier, the ratio being the reciprocal of that for loss. Thus, 20 TU gain is $\frac{1}{.01} = 100$ times, meaning that the output power is 100 times as great as the input power. For further information on TU see Martin, *Journal, A. I. E. E.* June, 1924).

If the cable mentioned were used without any correcting agency there would be a serious reduction in the strength of the high-pitch components which give music its charm and brilliancy. But frequency distortion, if not too great, can be offset by introducing an opposite distortion, a veritable case of two bad elements combined to achieve the desired good result.

To correct the frequency characteristic of short cable, special devices called "equalizers" are used. These consist of inductance, capacitance, and resistance, three of the elements forming a parallel resonant circuit, such as is familiar to radio amateurs from its use as a wave-trap. However, here the elements are so chosen that the resonant frequency is far lower, lying a little above the range of frequencies which the circuit transmits. As in a wave-trap, the impedance is high at the resonant frequency, so that here the equalizer introduces little loss since it is shunted across the line. But at lower frequencies the impedance is much less, and by proper adjustment of the two resistances and the equalizer is made to have characteristics just the opposite of those of the cable pair. The resulting curve for the cable with the equalizer is practically horizontal, which is the result desired. The volume is then raised to a higher level by a distortionless amplifier.

For the long connections between cities in chain broadcasting, "open wire" circuits are largely used, that is, circuits consisting of wire on insulators supported by cross arms. Most of this wire is hard-drawn copper (No. 6 B. & S.) 0.165 inches in diameter, the most rugged type of open wire line used in the Bell System. The energy loss along this type of line is much less than along an equal length of the cable just considered, but after the current has traveled about two or three hundred miles it must be reinforced. For this purpose an audio-frequency amplifier, called a "repeater," is used.

An open wire circuit is similar to cable in that the energy loss is greater at high frequencies, but somewhat different methods are used to make the open-wire frequency characteristic horizontal. Repeaters which introduce greater amplification for the high frequencies are used in conjunction with equalizers. These equalizers are different from the cable equalizer since the conditions are not the same.

TELEGRAPH AND AMPLIFIER ARRANGEMENTS

PARALLELING every long program circuit is a telegraph circuit over which reports and instructions are transmitted. With keys and sounders at every repeater station this provides an auxiliary communication channel for the use of those responsible for the program circuit. Other telegraph circuits connect the radio stations on each chain with the key station for the coördination of station announcements and other program details.

One of the most interesting features of a program network is the means employed to restrict the effect of an accidental short-circuit of the line at any point. Without the methods used, such a short-circuit, besides preventing any transmission beyond the particular point, would greatly reduce the voltage for a considerable distance back along the line. Now an amplifier, besides its primary purpose, has the important property that a change in the condition of the output circuit (such as a short), has practically no effect on the input circuit. So, wherever a program circuit forks, an amplifier is inserted into each outgoing branch, with the result that a short-circuit across one branch will not affect the transmission along the other branch. This is done regardless of whether or not amplification is needed—the one-way feature of an amplifier is taken advantage of in this way to increase the reliability of the system. For this reason repeaters average about 125 miles spacing in the East, when otherwise two or three hundred miles would be sufficiently close, for there are numerous forking points in this part of the country.

The drawing on page 67 illustrates, by a typical case, the manner in which the power decreases along each section of a program circuit and is built up to its original value at the repeater points. For example, at the New York repeater station the incoming power from the radio studio is given a net amplification of 9 TU, and then begins the trip to Troy, New York.

Along the circuit the power decreases steadily until at Troy it is only 3 TU above the original input at New York. Here it is amplified again, and continues on toward Syracuse. The maintenance of a horizontal frequency characteristic, the importance of which has already been stated, necessitates the introduction of losses at the repeater points which are offset by amplification; for simplicity these are not indicated, the net gain at each repeater station being shown. The final output power of the circuit at Chicago is seen to be four times greater than the input power at New York. The scale at the right gives for any point the number of TU by which the power at that point exceeds the input to the circuit at New York. The left scale gives the corresponding power ratio.

THE AMPLIFIERS OR "REPEATERS"

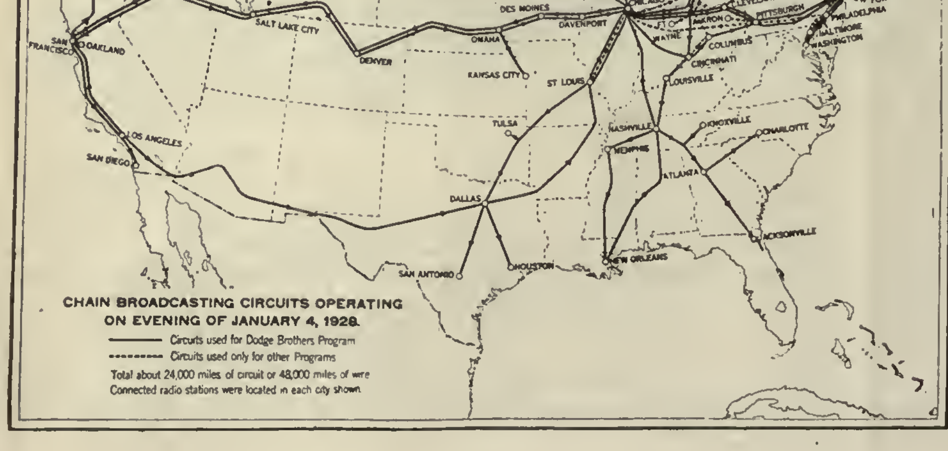
OF COURSE, the transmission of music and speech over program circuits is by alternating currents having frequencies the same as those which are present acoustically in the sound at the microphone. So the repeaters in the circuit are audio-frequency amplifiers. At the end of each program circuit in chain broadcasting is a radio transmitting station which sends the program out on the ether at a radio frequency.

Special study has been devoted to the design of telephone repeaters, and various types have been developed. Those used in program circuits are two-stage, transformer-coupled amplifiers using 130 volts plate supply. The first main element of the repeater is an input transformer whose secondary is tapped to allow adjustment of the amplification given by the repeater. The tapped voltage from this transformer is applied to a high-mu tube having an amplification factor of about 30, and an output resistance of about 60,000 ohms. From this tube the energy goes through an inter-stage transformer to the second stage. Here there is a tube having an amplification factor of about 6 and an output resistance of about 6000 ohms, similar to the 216-A or 112 type tubes which have been used in other amplifiers. There is an output transformer for delivering the amplified energy to the outgoing program circuit. Provisions are made for close adjustment of amplification and for adjustment of the frequency characteristic. The amount of amplification or "gain" in the repeater may be adjusted to any value over a range of 37 TU in steps of as little as 0.3 TU so that very accurate setting is possible. At 1000 cycles this adjustment varies the gain from 5 TU to 42 TU, which is the same as varying the power amplification from 3.2 to 15,800, or the voltage amplification from 1.8 to 126.

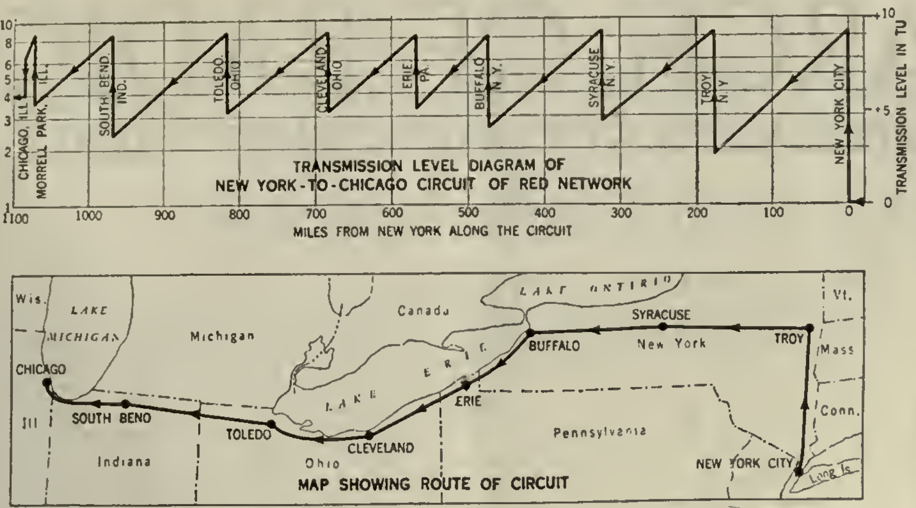
TESTING AND OPERATION OF PROGRAM CIRCUITS

A FEW years ago the testing and operation of all the program circuits then in use was in charge of one "transmission supervisor" located in New York. Since then, the extent of program circuits has grown by such bounds that it has become necessary to have additional transmission supervisors, and these are now located at Boston, Cincinnati, Detroit, Chicago, St. Louis, Atlanta and San Francisco. Each transmission supervisor is responsible for the program circuits going out from his control point. He, therefore, has charge of hundreds of miles of circuits and a number of repeater stations, through which the circuits pass. At each of the repeater stations there are trained men who are on duty during the hours that the program circuits are being tested or used, and these men make reports to the transmission supervisor, as directed, and adjust their apparatus in accordance with his instructions.

It is very important to maintain the program circuits in the best of condition, for many thou-



CHAIN BROADCASTING CIRCUITS OPERATING ON EVENING OF JANUARY 4, 1928.
——— Circuits used for Dodge Brothers Program
- - - - Circuits used only for other Programs
Total about 24,000 miles of circuit or 48,000 miles of wire
Connected radio stations were located in each city shown



WHAT HAPPENS TO ENERGY IN WIRE CIRCUITS

How the voice-frequency currents are attenuated as they travel over long lengths of wire. Note the effect of amplification at the repeater points

sands of radio listeners are dependent upon them. Each transmission supervisor, therefore, conducts every morning a thorough test and adjustment of all the circuits under his charge. Transmitting a tone of 1000 cycles over the program circuits, he receives reports by telegraph and directs adjustments at the nearest repeater station, then at the next repeater station, etc., until, in this way, the entire group of circuits under his charge is "lined up." Then a low frequency, about 100 cycles per second, is transmitted and any necessary auxiliary adjustments are made to see that this low pitch is transmitted with the same efficiency as the 1000 cycles. Then a high frequency of about 5000 cycles is transmitted to check the characteristics at this end of the frequency range, and if necessary, appropriate adjustments are made. Finally, music from a phonograph is sent over the circuits to give a working check on their condition.

The transmission supervisor is also responsible for the operation of the program circuits during use. As soon as a report of transmission difficulty reaches him, he must take immediate steps to correct it. Whether the trouble is noise on the circuit or low volume, he must proceed immediately with the proper steps. Sometimes the volume delivered by a circuit will diminish or the circuit will become noisy so as to suggest approaching failure. In this case he endeavors to obtain an alternative circuit and substitute it; sometimes this may be done before the radio listeners realize that any trouble has occurred. At other times a circuit may, without warning, fail completely, and at such times the transmission supervisor's general knowledge of the situation is put to the test. He may sometimes succeed in obtaining an alternative circuit with only three or four minutes interruption to the program. Sometimes alternative circuits follow different routes and far exceed in length the facilities they replace, such as during the Democratic Convention in 1924 when a connection 1400 miles long was substituted in place of one only 200 miles long. The transmission supervisors even keep informed of the weather conditions over a large part of the country so that, in case of threatening storms, they may obtain emergency routes and hold them in readiness.

The heading shows the program circuit control point at Chicago. Repeaters, equalizers, oscillators, transmission measuring devices, and other apparatus, may be seen mounted at the left and in the rear. One cone is connected to the Red Network program, another to the Blue Network, another to the Purple Network (the Columbia Chain), and the fourth is a spare. In this way, constant check is kept on the quality of the program transmission. At the right are telegraph operators who transmit messages between the transmission supervisor and the different repeater stations under his direction.

NETWORKS REGULARLY OPERATING

THERE are now four networks in daily operation, namely, the Red, Blue and Purple networks in the East, and the Pacific Coast network in the West. The eastern networks are supplied with studio programs from New York City and the Pacific Coast network from San Francisco. The total length of program circuits permanently connected into these four networks, or connected on a regular recurring basis, was, on April 1, more than 15,000 miles. To maintain and operate this great amount of program facilities required more than 25,000 miles of telegraph circuit. The daily audiences listening to the programs from these chains are estimated in the millions of persons.

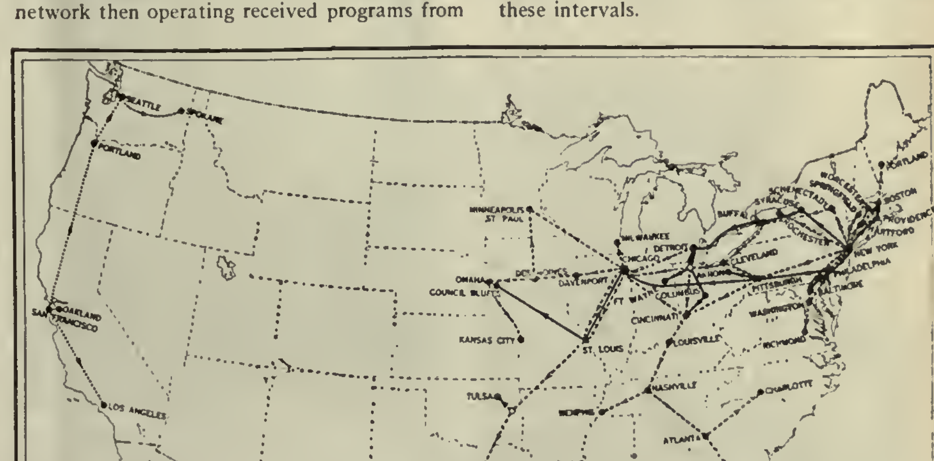
Perhaps the reader has wondered how the designation of networks by colors originated. This occurred several years ago when the only network then operating received programs from WEAF in New York. The telephone engineers drew in red pencil, on a map, the circuits regularly connected and drew in blue the extensions which were occasionally added. In this way the regularly operating chain became known as the "Red network." Later, when a network was organized with WJZ in New York as the key station, the name "Blue network" was, of course, given to this. At the important program control points the designation of the networks by colors is a considerable aid to the transmission supervisor in the necessary switching operations.

HISTORICAL SPECIAL HOOK-UPS

ON DEFENSE Day, September 12, 1924, two-way conversation between General Pershing in Washington and the Commanding Generals of the various Corps Areas in New York, Chicago, San Francisco and other points was transmitted to a number of radio stations and heard by many thousands of listeners. This occasion remains an unbroken record for the broadcasting of two-way conversation.

The largest number of radio stations ever connected was during the Radio Industries Banquet held in New York on September 21, 1927, when a total of 85 radio stations broadcast the proceedings. All four of the regular networks were used and 13 additional points were added.

Doubtless many readers will recall the first Dodge Brothers broadcast of January 4, 1928, when well-known persons in Los Angeles, New Orleans, New York, Chicago and Detroit were heard. The circuits used in this broadcast are shown in heavy lines in the drawing on this page, totaling over 20,000 miles of circuit, or over 40,000 miles of wire. Other program circuits operating on this date but not transmitting the Dodge program bring the total program mileage to about 24,000 miles of circuit or about 48,000 miles of telephone wire. In addition to this telephone mileage, about 40,000 miles of telegraph circuit was employed for lining-up and operating the program circuits. As the pick-up point was changed from one city to another, the circuits had to be switched at correspondingly widely separated switching-points. To perform these operations in the necessary order within the allotted five seconds required thorough training and a high degree of intelligence. All the pick-up circuits not in use for a few minutes were kept under continuous test to guard against the development of line troubles during these intervals.



CHAIN BROADCASTING CIRCUITS OPERATING IN THE UNITED STATES AT THE END OF 1927

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

Broadcasting Needs Capable Leadership

RADIO broadcasting is indeed a healthy structure to survive successfully the machinations of the politician, the cupidity of the direct advertiser, the absence of articulate listener sentiment and the regulation of an impotent and hesitant administrative commission. Only its real service to millions of listeners gives broadcasting its vitality. On every hand, radio is the victim of conflicting interests. The powerful, well-financed broadcaster is assailed for his supremacy by the less capable station; the vote-seeking politician, with a local point of view, hampers regulation by those who understand frequency assignment as a scientific and national problem; the ethical goodwill broadcaster is tempted by the example of the blatant radio advertiser. Only one influence can lead the way out of this welter of confusion and that is a crystallized listener sentiment.

In its riotous career, broadcasting has had many tormentors. Of these, the most disturbing is the belated and superfluous broadcasting station which has brought congestion, interference, and confusion. Throughout its history, broadcasting has lacked capable independent leadership to bring it through the wilderness of uncontrolled growth. It is illuminating to review the causes of present-day congestion because they point the way to a solution.

When radio held the center of the stage of public attention, the number of stations grew rapidly to the full capacity of the broadcast band. Room for greater power and more stations could be gained only at the cost of curtailing the service of an existing station. Two years ago, the fight of one station for another's time on the air upset the Department of Commerce's assumed authority over broadcast regulation, which was valiantly stemming the rising tide of stations. An effort was then made to preserve order by a gentleman's agreement among the existing stations. But the success of such a course was unfortunately predicated upon the requirement that all of those concerned be gentlemen.

During that period of chaos, broadcasting stations were erected with reckless abandon and total disregard of the capacity of the broadcast band. All broadcasting was conducted in a bedlam of shrill whistles and sullen groans. Stern parents punished their children by making them listen to the radio nightmare. But did a voice, representative of listener sentiment, arise in powerful protest? Did any leader of the industry face the facts squarely? On the contrary, the press was flooded with statements that there was really nothing wrong with the radio situation.'

After several months of torture, Congress began to grapple with the situation. But did anyone come forward with the insistent demand that the number of radio stations be promptly and emphatically reduced? The leaders of the radio industry unremittingly labored to get *some kind* of legislation passed. When debate centered upon two forms of regulation—by a commission politically subservient to Congress or by a government bureau reporting to a cabinet officer and relatively free of political instability—did the industry declare itself squarely against political regulation? Indeed it did not; it meekly favored both bills and, naturally, the bill giving political influence the greatest sway became the Radio Act of 1927.

Then came the *régime* of the Federal Radio Commission. Did the Commission display the courageous qualities of leadership essential to success in its onerous task? Its every act indicates that internal strife vitiated any constructive measures. For six months, it dabbled with its job. Credit must be given for its success in one respect; the Commission did manage to work out the best allocation possible *without* invoking the only course which would be successful—the elimination of excess stations in congested districts. The Commission talked about strong-arm methods one day and adopted weak-kneed policies the next; it announced that it would eliminate 300 stations from the broadcast spectrum and then promptly changed its mind. The progressive members of the Commission were invariably overruled because they could not successfully face the political pressure of Congressional overlords who invariably backed the weak against the strong.

When chivalry is applied to broadcasting, it means the support of less competent stations against the so-called chain monopoly. But to what stations does the listener turn his dials?

ANCIENT TRANSMITTING HISTORY

Parts of the first wireless telegraph installation in Porto Rico, built for and operated by the United States Navy. The station was located near San Juan and was completed in December 1903. The coil is the antenna tuning helix and below it is the spark gap case. To the left is the box containing the glass condenser plates. The spark gap was enclosed in the wooden box because of the terrific noise produced

He selects the powerful stations offering high-grade programs. As Representative Davis of Tennessee pointed out, two chain organizations, operating through seventy-two stations, slightly more than ten per cent. of the total number of stations on the air, have 50 per cent. of the total broadcasting power. The remaining stations on the air might be classed in two groups: promising independents, offering high-grade programs and worthy of expansion, and the small, advertising and propaganda stations, which now stifle the growth of the better independents. The predominance of the chain stations is founded entirely upon the crowding of the more worthy independent stations by the host of worthless ether busybodies. The elimination of 300 small stations, particularly in large cities where powerful locals exist, would give a well-balanced structure of chain and independent stations.

In all the vast amount of conversation precluding the passage of the amendment demanding equalization of broadcasting, no one succinctly and forcefully stated the position of the broadcast listener. The villification of the leading stations on the air went unchallenged. The equalization amendment is a farcical grandstand play, which glibly overlooks the fundamental causes of concentration of stations in the more populous areas. Merely to declare the sound principle that broadcasting shall be geographically equalized will not create the needed stations in the sparsely populated areas or the necessary channels so that they might operate.

To equalize the power in the five zones, only three possible courses exist:

> (1) Power in the weaker zones may be increased so that it equals that in the more progressive zones; (2) power in the strong zones may be reduced to the level of the weaker; or, (3) a middle course between these two extremes may be adopted.

Commissioner Caldwell showed that to bring up the power of the weaker zones to that of the highest would require the addition of 276 stations with 460,000 watts power. Inasmuch as the broadcasting band is already hopelessly overcrowded, any such increase, in fact any increase at all, would bring nothing less than chaos. Averaging the present total power among the zones would require a power cut in the first zone of 92,000 watts, curtailing the service of the most valuable stations on the air. At the same time, there are no stations in the South ready to bring that section up to average. Reducing the power of all districts to that available in the weakest would be wholesale destruction of good broadcasting.

The broadcasting industry should be encouraged to erect more great stations; the better independents should be given the opportunity to serve, unmarred by the excessive number of weaklings on the air. Unless the Commission develops an unlooked-for independence and courage, it will respond to the temper of Congress by hampering the growth of bigger and better stations. What we need is more, and not less, powerful stations in every section of the country. Only if listener sentiment becomes suddenly and

Present Distribution of Broadcast Stations

THE following is an analysis of broadcasting stations licensed as of February 29, showing the inequitable distribution of stations by zones.

Commissioner Sykes, representing the southern zone, has pointed out that every legitimate request for power increase and improved channels, made by southern stations, has been granted and that the inequalities are due rather to lack of progressiveness with respect to broadcasting in the South than to any discrimination.

	Population	Population (*per cent.*)	Area (*square miles*)	Area (*per cent.*)	Number of Stations	Total station power in Watts	Percentage of Station Power	Stations with Over 1000 Watts
Zone (New England Sts. N. Y. & N. J.)	24,378,131	22.73	129,769	3.63	138	213,055	35.30	10
Zone 2 (Central West & Middle Atlantic)	24,337,341	22.69	247,517	6.93	115	116,805	19.34	8
Zone 3 (Southern)	24,826,050	23.14	761,895	21.33	102	47,105	7.80	4
Zone 4 (Northwest)	24,492,986	22.83	658,148	18.42	215	164,870	27.31	30
Zone 5 (Western & Pacific Coast)	9.213.720	8.59	1,774.447	40.68	131	61,785	10.24	8
Total	107,248,228	100	3,571,776	100	701	603.620	100	60

immediately articulate, and a powerful sweep of opinion champions the two or three hundred favorite stations, can the destructive effects of the selfish and uninformed propaganda of Congress against good broadcasting be overcome.

Mergers in the Radio Industry

THE proposed merger of the Radio Corporation and the Victor Talking Machine Company would be a vital step in bringing us that combined broadcast receiver, phonograph, home motion-picture projector and television receiver which we forecast in these editorials for January, 1928, as the ultimate home entertainment machine. The total assets of the Victor Company are about sixty million dollars; those of the Radio Corporation about sixty-five million dollars. The merger will make available to the combination the services of renowned artists, both for radio purposes and for talking movies. The announcement that negotiations for this merger were under way was greeted with the usual monopoly accusations in Congress. Unquestionably the merger would result in a still stronger company. The consolidation of these interests is, however, certain to enhance the entertainment value of broadcasting and hasten the further development of diverse visual and tonal amusement in the home.

Another merger of vital importance to the American radio industry is the combination of the Marconi Wireless Telegraph Company of England with the Eastern Telegraph Company. This forms a one-hundred-million-dollar, worldwide communication corporation which may impose the pressure of severe competition upon the Radio Corporation of America. In spite of the comparative youth of the Radio Corporation, it has become a sufficiently vital factor in international communications to make this consolidation of British communications necessary.

A third merger which will ultimately affect the radio communication business is that of the International Telephone & Telegraph Company with the Mackay interests. The former controls telephone properties in Cuba, Spain, and South America and has exclusive rights for foreign manufacture of Western Electric Company products. The Mackay interests have an ambition to set up an international radio telegraph network and may ultimately become serious rivals to the Radio Corporation of America. The Mackay radio patent rights are based on their acquisition of the Federal Telegraph Company and Federal-Brandes.

More High Power Broadcasting

IT IS understood that the Crosley Radio Corporation, operating WLW, has applied for a 50,000-watt assignment and that, likewise, KFI in Los Angeles is to have a similar increase. The only southern station to seek a substantial power increase is KWKH. It is unfortunate that some of the more reputable broadcasting stations in the South are not aiming at substantial power increases, because there are many good reasons why KWKH in particular should not be favored by the Federal Radio Commission. This station, in plain defiance of the Commission, increased its power surreptitiously and utilized its facilities for villification of members of the Commission. It has established little reputation for high-grade programs, although it is by no means at the bottom of the list in that respect. We regret to see this progressiveness for much needed substantial power increases in the South largely confined to a station which has virtually thumbed its nose at the Federal Radio Commission and defied the simplest precepts of law and order.

British Skeptical of Baird Television Accomplishments

A PUBLICITY statement from the Baird company says that a picture of Miss Dora Selvey, transmitted by Baird television from London to the *Berengaria*, a thousand miles at sea, was considered recognizable by the radio operator. It must be realized that any kind of a radio transmission, which is interpreted by any form of television machine, makes some kind of impressions on the screen. The photographs of long distance television reception, published in the newspapers, which we have examined, have all been faked, the image drawn on the screen being the work of a retoucher. Newspapers, with a nose for news, however, do not hesitate to fool the public.

Popular Wireless, a British home constructor's magazine, offers to pay Mr. Baird £1000. if he will successfully televise by radio, over a distance of not less than twenty-five yards, certain items such as a series of three recognizable faces, five simple solid geometric models in slow motion, four animal toys, grouped and in slow motion, and a tray, containing dice and marbles to a number not exceeding twelve, all of these objects to be sufficiently clear that a committee of judges can recognize them and state their number. The same publication points out that the television sets being marketed in England, which are not true television but shadowgraph machines, require a high voltage supply of six or seven hundred volts, which is quite capable of giving a fatal shock.

Dr. Herbert E. Ives of the Bell Laboratories, who demonstrated the first television apparatus between Washington and New York in April, 1927, stated recently that bringing into the home by radio an actual spectacle like a great athletic event is unthinkable because its cost would be simply enormous. Television is most effectively accomplished through wire lines and displayed in theatres and auditoriums so that large numbers of people will divide the cost of the presentation.

WHEN the S. S. *Robert E. Lee* ran on the rocks while en route from Boston to New York on March 9, several broadcasting stations, tending to interfere with the handling of SOS traffic, were very slow in getting off the air. Among the stations named by the Federal Radio Supervisor, were WJZ, WRNY, and WGL.

© Harris & Ewing

THE FEDERAL RADIO COMMISSION IS COMPLETE

After long delay, the vacancy on the Commission was filled by the President and all the members confirmed by the Senate. *From left to right:* Sam Pickard, O. H. Caldwell, Carl H. Butman (secretary), E. O. Sykes, H. A. Lafount, and I. E. Robinson, chairman

Laxity in this respect is rarely displayed by the more important stations and the lesser, having high-frequency assignments, are least likely to cause dangerous interference. Since it may be a matter of life and death, leniency to those who fail persistently to shut down promptly for distress traffic should hardly be tolerated. The violations so far noted have been only spasmodic and quite accidental.

Here and There

THE Public Health Service broadcasts, which were begun in 1924, are now being used semi-monthly by fifty-four stations. 310 radio lectures have so far been delivered.

AS A result of the forty per cent. reduction in transatlantic telephone rates, there has been a fifty per cent. increase in the number of calls handled.

WCDA, a broadcasting station licensed in the New York area, for some mysterious reason, after the Federal Radio Commission went into operation, has sued WOR for $100,000. for an alleged harmonic, attributed to WOR, which causes heterodyne interference with its programs. WOR's frequency is 710 and that of WCOA 1420. As a matter of fact, two predominant heterodynes assail WCDA's carrier, both of which cannot be attributed to WOR. The technical standards, maintained by WOR, are beyond question and whatever radiation there may be on its harmonics, are certainly suppressed to the minimum which the present standards of the radio art permit. Should WCOA's pretentious suit be successful, it would inevitably lead to other suits because harmonics cannot yet be entirely avoided. The second harmonic of all stations, having a fundamental frequency lower than 750 kilocycles, falls in the high frequency end of the broadcast band. The successful prosecution of WCDA's suit would place in jeopardy all the broadcasting stations which are assigned to frequencies below 750 kc. WCDA should never have been given a license in the first place.

THE SET BUILDER IN DETROIT

EARLY in April, manufacturers of radio parts and accessories exhibited at Convention Hall in Detroit, featuring the newest a. c. developments, units for the use of custom-set builders, equipment for converting battery sets to a. c., parts for improvement of receiving sets now in use. The large attendance is indication of the power and numbers of the knights of the soldering iron.

A JOBBER section has been formed by the Federal Radio Trade Association. The manufacturers' relation committee of the section is headed by Harry Alter, the membership committee by J. M. Connell.

RADIO SALES IN FIGURES

THE average business done by radio jobbers is $218,000 annually, according to figures from a survey made by the Electrical Equipment Division of the Department of Commerce and the National Electrical Manufacturers' Association. Three hundred and seventy-five jobbers in New York, New Jersey and Philadelphia did an average volume of $298,000; the New England group $264,000; Great Lakes region $240,000 and southern states $118,000.

Small-town radio dealers, according to a survey by the same Bureau, average $5200 a year, as compared with $22,800 by the average New York dealers. The Philadelphia average was $21,000; Chicago $32,200. A group of cities, including Boston, Baltimore, Cleveland, Detroit and St. Louis, show an average of $44,300.

Radio Retailing estimates the sales of radio sets in 1926 at $506,000,000 and in 1927 at $446,550,000. Radio is now installed in 27 per cent. of American homes. If broadcasting conditions are not soon improved, radio set sales will continue to decline.

NO NEW IDEAS IN PROGRAMS

COMMENTING editorially on commercial broadcasting, *Editor & Publisher* states: "The rare incidence of new ideas in the program departments of large radio studios is beginning to worry the men assigned to the development of new converts in broadcasting. The monotony is beginning to pall on its makers and the feeling is expressed that the pall may extend to the payroll unless expert direction is found to steer programs into new channels. . . . As a rule, the radio program staffs are competent to provide a well-balanced evening of entertainment. They know nothing of selling merchandise and the application of advertising to the development of sales. They have constructed a program and stuck into it, like splinters into a fruit cake, occasional mention of the sponsor's name and goods. The advertising interludes to the entertainment have, in recent weeks, become more and more blatant."

Editor & Publisher's charges are, in the main, true. There have been very few instances of originality in the form of program presentation during the last few years. One answer may lie in the fact that successful moving picture directors get from fifty thousand to two hundred thousand dollars a year, while the number of program directors in the radio field who make more than five thousand dollars a yea an be counted on the fingers of two hands.

PENDING SHORT-WAVE APPLICATIONS

ONE hundred and fifty applications for short-wave channels by new commercial and public short-wave stations, requiring 350 channel assignments, are now pending before the Federal Radio Commission. Communication companies are making 45 applications for 137 channels; newspapers 31 for 97 channels; oil companies 28 for 29 channels; brokerage houses 12 for 22; steamship companies 7 applications for 13 channels; banking houses 6 applications for 6 channels; motion picture producers 5 applications for 10 channels; rubber companies 3 for 4 channels; coal 1 application for 2 channels; automobile and transportation companies 1 application for 1 channel; and miscellaneous businesses 5 applications for 7 channels.

If these assignments are granted and the channels placed in use, the rivals of these companies will also want channels and, since further channels will not be available, the Federal Radio Commission will, of course, be charged with discrimination. The principle of first come, first served, which must apply when a limited number of any commodity is being dispensed, always carries in its wake the cry of discrimination.

NEW AMATEUR BANDS

GENERAL order No. 24, by the Federal Radio Commission, opens the 20,000-to 30,000-kc. band to the amateur. The assignments are now as follows:

64,000—56,000 kc.	4.69— 5.35	meters
3,550— 3,500 kc.	84.5— 85.7	meters
2,000— 17.5 kc.	150 —175	meters

A SHORT-WAVE radio picture receiver, installed on the Hamburg American liner *Resolute*, is said to be successful. Small pictures and letters can be sent for moderate distances at a cost of one dollar.

THE NEW G. E. HIGH-FREQUENCY TUBE

DR. W. R. WHITNEY of the General Electric Company recently described a new high power, high frequency, short-wave tube, generating fifty million cycles. It radiates ten to fifteen kilowatts. Interesting psychological effects have been noted, particularly a warming

RADIO BRIGHTENS THE LIFE OF OHIO RIVER FOLK

House-boat dwellers along the Kentucky shore of the Ohio River. The receiver is pulling in WGY and is the first radio reception these folk have ever heard. The set was an important part of the equipment of Lewis R. Freeman, member of the Explorers' Club of New York who traveled from Pittsburgh to Cairo—a distance of 1000 miles along the Ohio River. This set was used to bring in weather forecasts while navigating the river and in one case, at Louisville, picked up a cyclone warning, enabling Mr. Freeman to avoid a tornado that might have destroyed his expedition

effect on the blood of persons within its influence. Small arcs are readily established by metallic conductors. Eggs and sausages have been fried by the heat generated on a single wire.

NEW RADIO AVIATION BEACON

THE visual indicator, developed by the Bureau of Standards of the Department of Commerce, to show the aviator his course, employs a needle-like reed, moved by electrical impulses received from the radio beacon. It does away with headphones and trailing antenna. It works on the familiar balanced signal principle and gives indications for distances of fifty miles. In mountainous regions, however, its directional accuracy varies but the device should be of inestimable help in locating a landing field through a fog when the aviator is not far distant from the field. Guided by the beacon, he can come within range of the fog-penetrating neon light and thus make a successful landing which might not be possible without the radio direction finder.

OWEN D. YOUNG flatly stated recently that the British lead America in international cable and radio communication. "The English Government," said Mr. Young, "fearing predomination of the American radio group in the world of communication, has practically coerced the interests in England to combine cables with radio in order that the English domination of cables may continue. In America, Congress has enacted directly a piece of legislation stipulating that there can be no coöperation or relation between the cables and radio. Congress had distintegrated our strength into small units and put each one of them at the mercy of a large centralized foreign group."

GOVERNMENT officials in Czecho-Slovakia estimate that the saturation point in the possible number of receiving set owners has been reached in that country unless more broadcasting stations are erected. There are now 206,000 listeners in Czecho-Slovakia which has a population of some thirteen million.

RUMORS have appeared in the press that several large holders of R. C. A. licenses have stopped payment on their license contracts and served notice to the effect that at the present time they are not able to carry out their agreements because of heavy declines in sales and the inability to realize on large stocks of battery sets.

THE Brunswick Phonograph Company announced that it will place records of certain commercial broadcast programs on the market the day following their presentation. It's bad enough to hear most radio programs but once!

BRITISH SHORT-WAVE EXPERIMENTS

WITH characteristic caution, the British broadcasting monopoly announces, through its Chief Engineer, Captain Eckersley, that the 5 sw high-frequency transmissions are being attempted largely to permit foreign and dominion experts to ascertain field strength on various frequencies. "It would be criminal foolishness," says the announcement, "to let these encourage one into saying that there is yet a guarantee of satisfactory service worthy of the object served."

International broadcasting, through short-wave interconnecting links, is still a spectacular demonstration with all the hazards of uncertainty. But any new art must begin in this way and the experiment should he encouraged. Its success will accomplish much more than all the peace conferences and pacifist disarmament propaganda.

BROADCAST AREA SERVED IN AUSTRALIA

THE interests operating station 3 LO in Melbourne, Australia, have shown, by superimposing a map of Europe upon that of Australia, that six Australian broadcasting stations, all fringing the coast, serve an area equal to that of Europe, including Great Britain and Ireland. Most of the population of Australia, however, is distributed in centers along the seacoast. There is no problem of frequency shortage to hamper the increase of broadcasting stations, but it appears that the government authorities hesitate to permit an increase in the number of broadcasting stations.

BROADCAST COÖPERATION IN EUROPE

THE Union International de Radiophonie, which consists of delegates from all European countries operating broadcasting stations, is concerning itself with such problems as frequency assignments, accurate frequency measurements and the formulation of the frequency requirements of the various nations. This body serves the same function as the Federal Radio Commission in the United States, except that it has no legal authority and must settle its affairs by mutual agreement and conference.

PCJJ, the Dutch short-wave broadcasting station, frequently heard by American enthusiasts, has adopted a schedule as follows: Tuesdays and Thursdays, 16 to 19 Greenwich mean time, and Saturdays 14 to 17 G. M. T.

AUSTRIA now claims to be the most progressive country in the broadcasting field, so far as percentage of registered listeners is concerned. 300,000 out of its 6,500,000 population are registered radio listeners. Radio manufacturing is also developing rapidly, exports being four times greater than imports.

FACSIMILE TRANSMISSION USED

THE extent to which financial enterprise is utilizing the modern means of electrical communication is illustrated by the recent floating of ten million dollars in bonds for Warsaw, Poland, simultaneously in Europe and America. A 1400-word descriptive circular was compiled and sent by radio to London and Stockholm. Quarter-page ads were then set up in London and mats made and distributed by air mail to other European capitals. The circular was cabled to South America and put into type. In New York, it was set up and distributed by telephoto to cities as far west as the Pacific Coast. Thus transatlantic radio picture circuits, airplanes, telephoto, and cable were used in this international financial venture.

THE transatlantic telephone service was extended to Belgium on January 19 and to Holland on January 30.

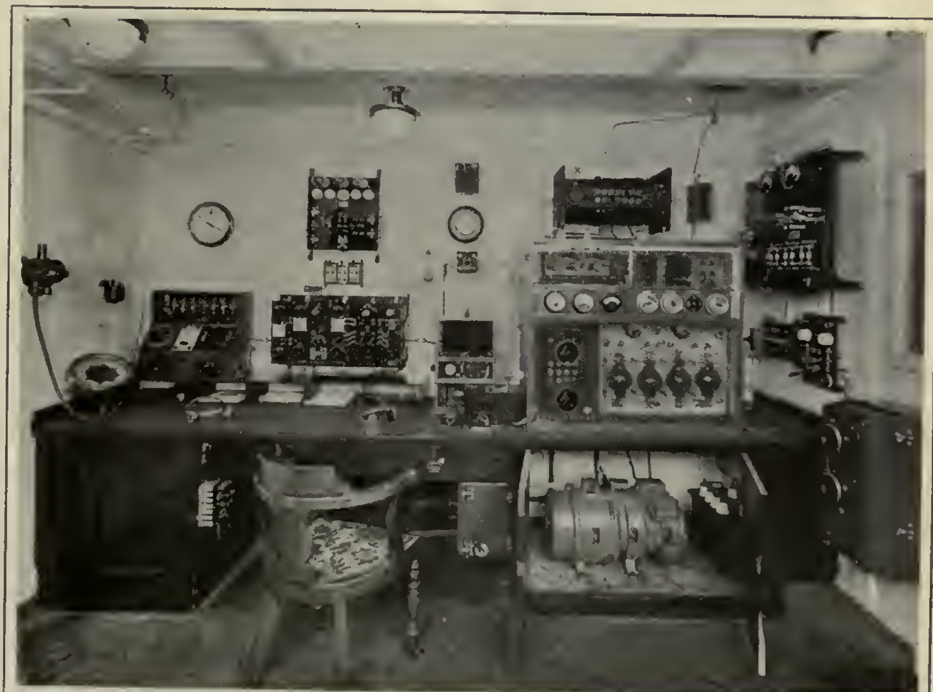
HERBERT H. FROST, formerly General Sales Manager of E. T. Cunningham, Incorporated, has resigned to become Vice-President of Federal-Brandes, Incorporated.

RADIO beacon service is to be installed along the French coast. One station is to be built at the mouth of Cherbourg harbor and another ten miles northeast of that point so that bearings can be given to incoming ships.

A DECISION of the U. S. District Court in Cincinnati declares that the Crosley Musicone does not infringe upon the Lektophone patents. The Musicone, says the decision, is drawn from the same prior art that the Hopkins invention is made and is an improvement thereof.

The Supreme Court of Canada holds that the patent granted by the United States to the German inventors Schoelmich and Von Bronk is prior art over the Alexanderson tuned radio frequency patent. This is directly opposite to the opinions of American courts.

—F. H. F.



RADIO CABIN OF THE MOTORSHIP "BERMUDA"

This is the latest type Marconi installation for ships and shows (left to right) gyro-compass repeater; direction finder; receiver operating on all wavelengths from 300—20,000 meters; ½-kw. quenched spark transmitter; 1½-kw. c.w. and i.c.w. tube transmitter working between 600 and 2200 meters

Automatic Tuning for the Radio Receiver

By LEROY S. HUBBELL

IF WE review the development of the mechanics of a radio receiving set we remember a panel resembling a small switchboard which had primary and secondary inductance switches, an A battery control switch, several variable condenser controls and other minor control switches. Gradually, over several years, these numerous controls began to disappear until now, on the panels of many of the recent designs, not more than three controls exist, namely, the on-off switch, a single dial for controlling the variable condensers, and sometimes a volume control.

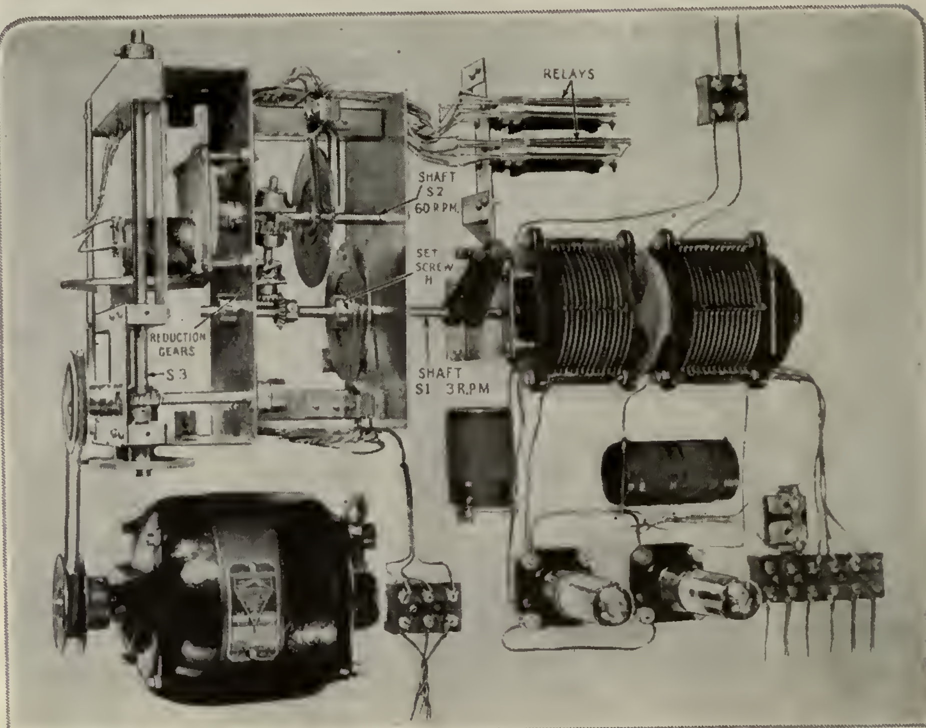
While there have been many improvements toward simplifying the tuning of a radio receiver, it is still necessary to manipulate a dial and if a particular station is desired it is necessary to consult a schedule. If no tuning schedule is available the settings are oftentimes haphazard. In a large number of cases, particularly in the metropolitan areas, the dial settings are usually confined to not more than five to ten stations.

When one is comfortably seated, whether in a favorite armchair by the fireside or at the table enjoying a dinner or participating in a card game it is annoying to interrupt one's activity to adjust the radio to some other station in search of a more delectable program. The partial elimination of the multi-controls on the radio receiver has reduced immensely the trials and tribulations of many a lover of radio entertainment. Probably there will always be at least two controls, one for the station setting and another for the volume from the loud speaker. Take these two controls to the armchair by the fireside or to the table and the ideal radio entertainment is at hand.

In this article we discuss a means for automatically tuning a radio receiver at a remote point, although the same equipment may be used in connection with a transmitting station where the tuning elements are adjustable. The advantages may be summarized as follows.

1. The set may be tuned to any one of several definite stations by pressing a button.
2. The set may be controlled at any point of convenience.
3. The radio receiver may be housed in a closet or other out-of-way place reducing considerably the cost of expensive furniture.
4. An outdoor directional loop type antenna may be used instead of the present antenna.

[Judged by present standards, Mr. Hubbell's automatic tuning mechanism has certain drawbacks, as well as obvious advantages. These limitations hold for all automatic tuning mechanisms with which we are familiar. The apparatus takes up considerable space, and although, as Mr. Hubbell suggests, the receiver and the tuning mechanism may be located elsewhere than in the living room or the den—or wherever receivers now in common use are located—it is necessary to place the automatic mechanism quite close to the radio apparatus and in most cases that involves rearranging at least the radio frequency and detector circuits of the receiver. Neither Mr. Hubbell's arrangement or any other can readily be applied to the average existing receiver. That is, of course, not a serious disadvantage, for it is not difficult to rearrange a "pet circuit" so that the relay tuning controls are operative. Cost, too, is a factor, but a very real gain in convenience is achieved which should equalize that.—*Editor.*]



AN EXPERIMENTAL SET-UP OF THE HUBBELL AUTOMATIC TUNING CONTROL

The photograph shows a rough model of the tuning control apparatus and the radio and detector circuits of the receiver. The motor in this illustration is much larger than necessary. The model shown is equipped for tuning only to one broadcast station. For each additional station, two more cams, one on each shaft will be required and one additional relay for each station

THE APPARATUS USED

THE equipment designed by the author for automatically tuning radio apparatus consists essentially of a small commercial type motor of about $\frac{1}{30}$ h.p. or less, depending on the number of stations the equipment must tune to, connected to a revolving iron disc through a reduction gear. The revolving iron disc is caused to engage at right angles another iron disc by means of an electro-magnet (magnetic clutch). The second disc is connected to a series of cams to which spring contacts engage. Two cams, one acting as a vernier to the other and a relay are required for each wavelength setting. If the radio apparatus has more than one variable control the clutch and cams are duplicated, but the motor and reduction gear are common to any number of controls.

OF LATE there has been a considerable interest in the automatic tuning of radio receivers. Remote tuning control of radio transmitters has been used for some time, in various forms by both commercial and military radio stations, but until recently, little had been done to explore the possibilities in the radio receiver. This timely article by Mr. Hubbell describes the mechanical principles of the system which he has devised; the illustrations show a rough model. A commercial model would probably be quite different in arrangement and appearance. Practically, the device suggested by Mr. Hubbell is limited to the control of from ten to fifteen stations, but it does permit the manual control of the receiver at any time. No effort has been made to treat this subject from the constructional point of view. Our readers will nevertheless be interested in the description of the present method. All patent rights are reserved by the author.

—THE EDITOR.

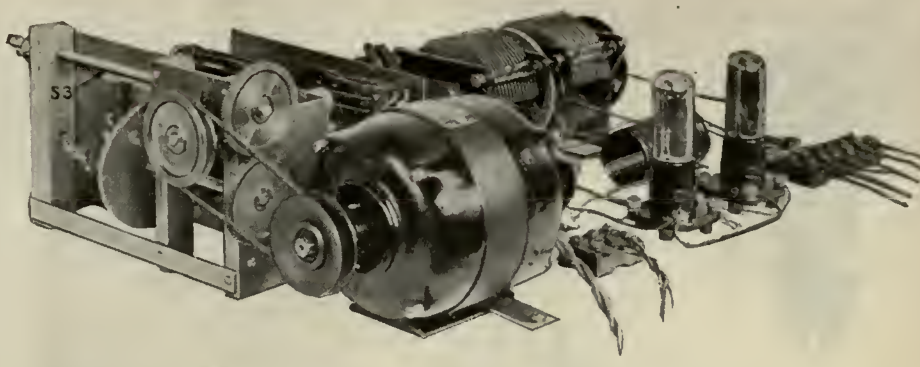
At a distance from the radio set there is a small button box which contains a button for each wavelength and associated with each button is a small display lamp to indicate the station to which the set is tuned. The button box also contains a rheostat or potentiometer for controlling the volume at the loud speaker.

Except for the push buttons, display lamps and volume control switch, the tuning mechanism may be housed within the radio cabinet. For those who are not interested in distant stations and confine their entertainment to local broadcast programs it would be practical and desirable to place the radio equipment in a closet or other out-of-sight place thus reducing the cost of the receiver.

In the accompanying Fig. 1 is shown the fundamentals underlying the operation of the automatic tuning equipment designed by the author. In the lower left hand side of the drawing is shown a revolving iron disc, D_1, whose shaft is connected to a small motor (not shown) through a reduction gear. When the motor is energized, the iron disc to which it is connected revolves at about 60 revolutions per minute. Adjacent to this disc is another iron disc, D_2, the axis of which is at right angles to the former. These two discs have about $\frac{1}{32}$" clearance between their edges. There is a magnet, M_1, mounted closely against the driving disc, but not touching it, with one of its poles facing the driven disc. There is a return pole piece on

the magnet to concentrate the flux at the driven disc end. On the driven disc there is mounted a six-fingered suspension spring which connects at its center the shaft, S, to the driven disc at the extremities of the fingers. This spring permits the driven disc to hold up against the driving disc when the magnet is energized.

On the shaft, S, a cam is mounted consisting of copper punchings riveted to a fiber disc. The front of the cam is shown in perspective while the rear of the same cam is shown at the right of the drawing in full view. On the front of the cam it will be noted that the copper punchings are cut so that the brushes resting against the cam pass over segments and interrupt any current which may be passing through the brushes. On the rear of the cam there are no breaks in the copper punchings. These copper punchings are electrically connected to the punchings on the front of the cam by rivets. In the upper portion of the drawing a conventional relay is shown. In the lower right hand side a push button and a display lamp is indicated. The shaft, S, is connected to the proper variable tuning element of the radio set such as a variahle condenser, a variometer, etc.



A SIDE VIEW OF THE EXPERIMENTAL UNIT

This illustration shows the mechanical relation of the reduction pulley and the main shaft, S_2

TUNING FOR STATIONS

BY PRESSING the push button a circuit is closed beginning with the ground side of the battery through the contacts of the push button, and the relay to battery. The relay operates and in so doing establishes a circuit to lock itself up. The circuit is as follows: beginning with ground at the left of the relay through the making contacts to the upper spring pressing against the rear of the cam, through the rivets of the cam to the upper brush on the front of the cam back to the right hand contact spring of the relay, through the winding of the relay to battery.

At the same time that ground is connected to the upper brush on the front of the cam, a ground is placed on the middle brush which operates the magnet. Also a ground is supplied to the motor lead which operates a relay in the motor circuit causing the motor to rotate. The shaft, S, now rotates and continues to rotate until the top and middle brush fall into the open-shaded segment of the cam. The set screw, A on the cam hub permits the cam to be set at any angular adjustment so that the variable element in the radio set can be rotated to any predetermined setting. In practice there is another shaft, S_2 (see the accompanying illustrations) paralleling the shaft, S, on which is mounted a similar cam and brushes. The second shaft is connected to shaft S, through a gear, reducing the speed from 60 r.p.m. to 3 r.p.m. The brushes of the second cam are connected in multiple with the brushes shown so that by connecting the variable condenser or other variable element to the second shaft, a micrometer adjustment is obtainable.

When the cam on shaft S has arrived at the break in the copper punching the circuit to the motor, clutch and relay is opened. A contact is made however on the lower brush at both sides of the cam which completes a circuit from the ground at the relay (the relay now being released) through the lower brushes on the front and rear of the cam through the display lamp to battery. The display lamp is lighted to indicate that the variable element in the radio receiver is tuned to a wavelength as predetermined by the adjustment of the cam on shaft S.

It should be noted that the lead marked "To battery switch" is connected to battery through the released contacts of the relay. With this arrangement all undesirable noises in the loud speaker are eliminated when the variable elements are passing over unwanted stations. As soon as the cam has arrived at its predetermined station setting the relay releases and through its contacts supplies current over lead "To battery switch" to the A battery rheostat.

The push button and display lamp indicated in the drawing together with a plurality of push buttons and lamps are mounted in a button box away from the tuning equipment, the latter as suggested above are housed within the radio cabinet. From the push button box there are two wires for each button, a pair for the two poles of the battery and a lead for controlling the volume at the loud speaker. For a six-station controlled set, there would be about 15 wires in a flexible silk covered cable leading from the position of the button box to the radio set.

The relays used are of commercial manufacture having resistances of approximately 200 ohms and operating on 6 volts. The magnet is part of the construction of the tuning mechanism and is wound to operate on a 6-volt battery at about 15 watts. The battery used may be either a 100-ampere storage battery or may be replaced by an a.c. rectifier which would operate only when required. Low voltage a.c. for operating the relay and lighting the display lamp would also be required if the storage battery is eliminated.

In the photographs, the relays referred to and the magnetic clutch are marked. The motor, which rotates at about 1750 r.p.m. is connected to the device by means of a belt. Between the motor shaft and the driving disc shaft the speed is reduced to about 60 r.p.m. through the pulleys on both the motor and the device and the reduction gears on the device itself. The magnetic clutch being energized by the relay as mentioned above, is holding the driven disc up against the driving disc causing the cam on the left hand shaft to revolve clockwise and the cam on the opposite shaft to revolve counter clockwise.

The cam on the left hand shaft revolves at about 60 r.p.m. while the cam on the right hand revolves about 3 r.p.m. the reduction taking place through the gears connecting the two shafts.

It will be noted that the tuning device and the variable condensers are not directly connected. The means shown permits a free movement of the condensers through nearly 360 degrees. By this feature it is possible to tune the radio set manually to any desired station free of the automatic tuning device. The experimental model is equipped to tune-in automatically only one broadcast station, that station being dependent upon the settings of the two cams. For each additional station two more cams, one on each shaft will be required. One additional relay will also be required for each additional station. The practical limit is probably about 10 or 15 stations.

For cases where there is another adjustable tuning element in the radio set and which can not be directly connected to a single control, it is possihle to tune automatically that element independently. To do this a shaft is extended to another device which is similar to that shown. In this case, however, the only parts which require duplication are the cams and magnetic clutch and the spur gears which connect the upper shaft to the driving disc shaft.

The second relay shown in the photographs is connected between the push button relay (shown in diagramatic form in Fig. 1) and the motor. The use of this relay merely separates the direct current circuit used to operate the radio set from the 110-volt alternating current lighting circuit which is used to operate the motor.

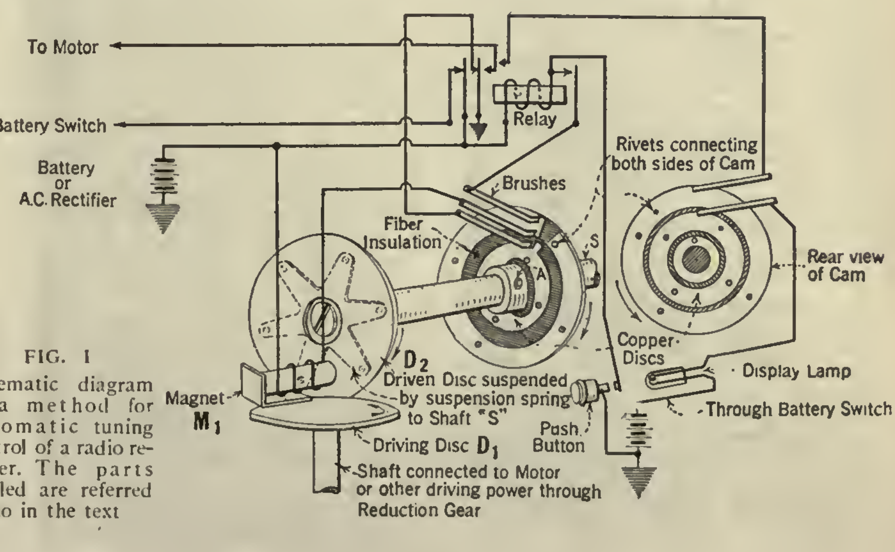


FIG. 1

Schematic diagram of a method for automatic tuning control of a radio receiver. The parts labeled are referred to in the text

THE NEWEST POWER TUBE

By Howard E. Rhodes

Radio Broadcast Laboratory

THE UX-250 (CX-350) "special purpose" tube is the newest and probably the last of the line of power amplifier tubes designed for use with radio receivers, for according to its designers, the power output is about as large as may be obtained from a tube mounted in a standard receiving tube base. The glass bulb enclosing this tube, which determines the amount of heat that can be dissipated, is as large as is feasible using this base.

To what use can this power tube be put? What advantages and disadvantages has it over other types? Let us compare it with others to get a clear picture of the relation between the 250 and other tubes.

Fig. 1 shows how the power output of this tube compares with that of the other types of power tubes at various plate voltages.

TABLE I

Plate Voltage	Undistorted power output in milliwatts			
	112	171	210	250
90	40	130		
135	120	330		
157	195	500	90	
180		700	140	
250			340	900
350			925	2350
400			1320	3250
450			1760	4650

The figures in Table 1 together with data on several push-pull combinations have been plotted in Fig. 1. This graphic representation of the power output of various tubes and combinations of tubes, as a function of plate voltage, serves well to illustrate the relative position of each tube from the standpoint of power output.

When interpreting these curves, it should be appreciated that a considerable increase of power output is necessary in order to make the effect appreciable to the ear. Twice the power output is equivalent to an increase of 3 TU which is not very great, 1 TU being a just audible increase. It is necessary that the available power be increased two or three times in order for the increase to be worth while.

The choice of which type of tube is used depends, obviously upon how much power output is desired. If not more than 200 milliwatts are required, the 112 may be used; for a power output up to 700 milliwatts the 171 type tube is used. If greater power than this is required we can use either a 210 or a 250 type tube. A more detailed analysis of these two tubes, showing how their power output varies with the applied plate voltage is given below.

POWER OUTPUT OF 210 TUBE

Plate Voltage	Power Output (Milliwatts)	Plate Current (mA)	Grid Bias (volts)
250	340	10	18
350	340	16	27
450	1700	18	39

POWER OUTPUT OF 250 TUBE

Plate Voltage	Power Output (Milliwatts)	Plate Current (mA)	Grid Bias (volts)
250	900	28	45
350	2350	45	63
450	4650	55	84

This table is very interesting for it shows that at all plate voltages, the 250 tube is capable of delivering more than twice the power output of a 210 tube. For use in a straight amplifier (not push-pull) the tube, from the analysis given above, seems to be much the best for it is capable of delivering much more power than any other type of tube. When operated at maximum voltage, the 250 can deliver a power output of 4.6 watts which is about as much as can be obtained from two 210 type tubes in push-pull. In the following paragraphs a more complete comparison is given of a single 250 *vs.* 210's in push-pull.

POWER SUPPLY EQUIPMENT

ABOUT 450 volts are required in both cases and the plate current requirements (about 40 mA. for 210's in push-pull and 55 mA. for a single 250) are not sufficiently different to make the power supply equipment much cheaper for one of the two arrangements. In so far as the power supply is concerned, therefore, there is no distinct advantage in favor of a single 250 rather than two 210's in push-pull or vice versa.

A COMPARISON OF COST

SINCE ordinary transformers are cheaper than push-pull transformers it is somewhat less expensive to construct a power amplifier using a single 250 type tube than two 210's in push-pull. For example, suppose that transformers costing about as much as Amertran's were to be used in the amplifier,

SINGLE 250 TUBE

Input transformer	$10.00
Output device	10.00
One 250 type tube.	12.00
One socket	1.00
Total	$33.00

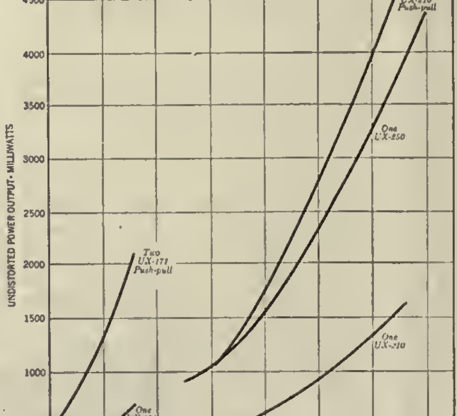


FIG. 1

How the power output of the 250 type power tube compares with other types of power tubes, at various plate voltages

210'S IN PUSH-PULL

Input transformer	$15.00
Output transformer	15.00
Two 210 type tubes	18.00
Two sockets	2.00
Total	$50.00

Here we see a distinct advantage in favor of a power amplifier using a single 250 tube and delivering to the load about as much power as 210's in push-pull, which will cost only about 65 per cent. as much as a push-pull amplifier.

A COMPARISON OF QUALITY

IN THIS characteristic, the push-pull arrangement is theoretically better than the single tube because the former arrangement eliminates second harmonic currents—currents which represent distortion and which are passed on to the loud speaker when only a single tube is used. However, even with a single low-plate-impedance tube such as the 250, there isn't much second harmonic current generated by the tube in the load circuit when the tube is delivering its rated power, or less for under the condition that the tube is working into a load impedance approximately twice as great as the tube's plate impedance the amount of second harmonic current in the output is not greater than 5 per cent.—an amount of distortion which is considered small enough not to be appreciable to the ear. If the load impedance is smaller than twice the tube's impedance, there is more distortion; if it is equal to the tube's impedance, the amount of distortion due to second harmonic currents will be about 15 per cent., this latter figure being calculated from some curves on the tube to be published in the *Proceedings of the I. R. E.* ("Development of a New Power Amplifier Tube," Hanna, Sutherlin, and Upp). The impedance of many loud speakers, at the very low frequencies, will be about the same as that of the 250 type tube (2000 ohms) and therefore there will be about 15 per cent. second harmonic current generated by the tube. However, the sounds created by musical instruments contain many harmonics and the ear itself probably generates others, so it may be that the above figure of distortion is not large enough to be serious.

The 210 push-pull arrangement has an advantage over the single 250 when the filaments are to be operated on raw a. c. In the push-pull amplifier, any hum due to the a. c. operation of the filaments is cancelled out, while with the single tube arrangement this does not occur. However, the 250 tube uses a heavy ribbon type filament (similar to that used in the 280 type tube) which has a high thermal inertia tending to prevent the production of any a. c. hum when its filament is operated on raw a. c. The 250 type has a low plate impedance, (about 1800 ohms) and can therefore be used with ordinary loud speakers without any need of an impedance-adjusting transformer. Two 210's in push-pull have a plate impedance of about 10,000 ohms and in this case it is best to use an impedance-

adjusting output transformer to adapt the tube impedance to that of the loud speaker. Although an impedance adjustment is not necessary when using a 250 type tube, it is necessary to use an output device to protect the windings of the loud speaker from the high plate current of the 250 tube.

COMPARISON OF SENSITIVITY

UNDER this caption we discuss how the two arrangements compare with regard to power output for a given input voltage. Let us, therefore, calculate the power output, for a given input, for both arrangements. If each arrangement works into a load impedance equal to twice the tube impedance, then, per volt input squared, there will appear in the load the amounts of power, as indicated below.

ARRANGEMENT	POWER IN LOAD, PER VOLT SQUARED, ON GRID OF TUBE
Single 250	0.8 milliwatts
Push-pull 210's	3.0 milliwatts

In this table the 250 shows up very poorly, being only about one-quarter as sensitive as 210's in push-pull. However, the turns ratio of the average push-pull input transformer available to-day is lower than an ordinary transformer and if we assume that with a single tube the input transformer has a ratio of 4 and that the push-pull transformer has a ratio of 2 (many push-pull transformers have a lower ratio than this) between the primary and one side of the secondary, we then obtain the following figures:

ARRANGEMENT	POWER IN LOAD, PER VOLT SQUARED, ACROSS TRANSFORMER PRIMARY
Single 250	12.8 milliwatts
Push-pull 210's	12.0 milliwatts

These figures give a truer picture than those given previously. The difference between the two arrangements—a matter of 0.8 milliwatts per volt squared—is too small to be appreciable to the ear but at least we may be sure that an amplifier using a push-pull arrangement wilth average transformer ratios and with 210 tubes won't give any greater volume, with a given input, than an amplifier using a single 250 tube.

This analysis, summarized in the accompanying table, shows the 250 tube to be about equal to a 210 push-pull amplifier in most respects excepting that of cost.

The complete characteristics of the 250 tube are given in the table accompanying this article which shows that this tube requires a plate voltage of about 450 volts and takes a plate current of 55 mA. The power supply must provide this amount of current and voltage. The loud speaker must be isolated from this high plate current by an output device.

In some cases it will be found possible to substitute a 250 type tube for a 210 tube in an amplifier, but frequently this will not be possible because the 250 takes three times as much plate current as a 210 and the rectifier-filter system may not be able to supply sufficient voltage at this higher current drain. The higher current drain may reduce the voltage output of the power unit from 450 volts, when a 210 type tube is used, to 300 volts or so and it is not worth while to operate a 250 at this voltage. Under such conditions the tube cannot deliver much more power output than a 210 type tube, operated at 450 volts.

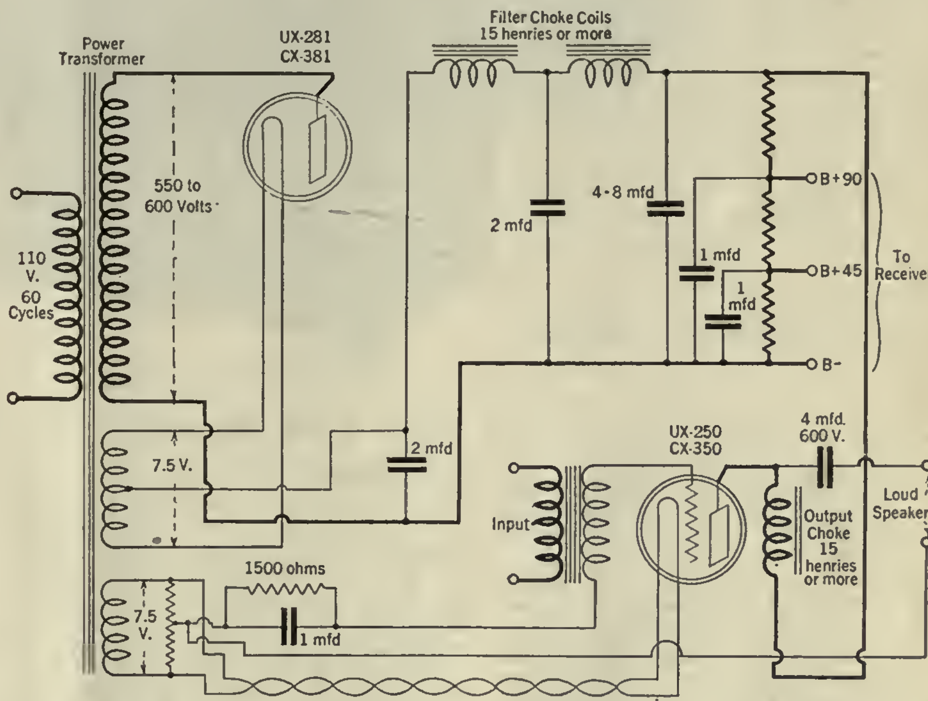
ALLOW ONE WATT PER LOUD SPEAKER

THE 250 type can be used in a properly designed push-pull amplifier and such a use for the tube should prove useful where sufficient power is required for the operation of several loud speakers or for auditorium work. A push-

CHARACTERISTICS OF THE TYPE 250 TUBE

	RECOMMENDED				MAXIMUM	
Plate Voltage	250	300	350	400	450	Volts
Negative Grid Bias	45	54	63	70	84	Volts
Plate Current	28	35	45	55	55	Milliamp.
Plate Resistance (a–c)	2100	2000	1900	1800	1800	Ohms
Mutual Conductance	1800	1900	2000	2100	2100	Micromhos
Voltage Amplification Factor	3.8	3.8	3.8	3.8	3.8	
Max. Undistorted Output	900	1500	2350	3250	4650	Milliwatts

Filament	7.5 Volts	1.25 Amperes
Max. Overall	Height 6$\frac{1}{4}$"	Diameter 2$\frac{11}{16}$"
Base	Large Standard UX	



GENERAL CIRCUIT REQUIREMENTS FOR THE 250 TYPE TUBE
All values are indicated except the voltage dividing resistances which vary according to the receiver to be supplied

Comparing the 250 Type Tube With Other Power Tubes

IN THIS article the new type 250 power amplifier tube is compared with other power tubes now available. A summary of the points developed more fully in the article follows:

(*a*). The maximum power output of a type 250 tube is 4.6 watts, which is about three times as much as can be obtained from a 210 type tube and about seven times as much as can be obtained from a 171 type tube.

(*b*). The power output of a single 250 is about equal to the power that can be obtained from a push-pull amplifier using 210 tubes.

(*c*). The power supply equipment necessary for the operation of the 250 type tube is about the same as is required for the operation of a push-pull amplifier with 210 type tubes.

(*d*). Because ordinary transformers are generally cheaper than push-pull transformers, it is cheaper to construct a power amplifier with a single 250 type tube than it is to construct a push-pull amplifier with 210's.

(*e*). An amplifier using a 250 will give excellent quality. When the tube is worked into a load impedance equal to twice the tube's plate impedance, rated output will be delivered to the load without creating more than 5 per cent. of second harmonic current.

(*f*). The volume output of a single-stage amplifier using a 250 will be about equal to that from a push-pull amplifier with type 210 tubes, assuming that the input voltage is the same in each case and that the transformer feeding the 250 has a ratio of 4 and the input push-pull transformer has a ratio of 2 (average figures).

(*g*). A single 250 tube will supply all the power, with plenty in reserve, that will be required for the operation of any radio receiver in the home. Where only moderate volume is required, smaller tubes such as a 171, may be used but where reserve power is desired to take care of greater volume, the type 250 may be used.

pull amplifier with 250 type tubes will be able to deliver to a load about 12 watts of voice frequency power—which is no mean figure! A push-pull amplifier using 210 type tubes, outputting about four watts, can be used to supply about four loud speakers, and a push-pull amplifier with 250 tubes will be able to supply about fifteen loud speakers, assuming in both cases that each speaker will require about one watt of energy. In a home installation a single 250 tube should give all the power that will ever be required, with plenty in reserve.

Several manufacturers have already announced apparatus suitable for use with the 250 type tube. The General Radio Company has designed a complete line of transformers, filter units, and output devices for use with the 250 tube and a description of this apparatus will be found in the New Apparatus section of this issue.

The Silver-Marshall Company has designed two amplifiers for the use of the 250 tube; one a single-stage affair, and the other a complete two-stage amplifier. The two-stage amplifier is illustrated herewith. It uses a type 226 tube in the first stage and a 250 in the second stage. Plate supply is obtained from a rectifier-filter system using two type 281 tubes in a full-wave circuit. A glow tube is used. The single-stage amplifier is similar to the two-stage unit that is illustrated except that the apparatus for the first stage is omitted. This latter amplifier may well be used to replace an unsatisfactory last-stage amplifier in any radio receiver. From both of these amplifiers can be obtained the necessary B voltages for the operation of the other tubes in the receiver proper, and in addition the two-stage amplifier will also supply a. c. voltages for the filaments of any a. c. tubes that may be used in the set. The two-stage amplifier is also especially satisfactory for use with a phonograph pick-up to play phonograph records. Both of these amplifiers can be home constructed with little trouble, from data obtainable from Silver-Marshall through Radio Broadcast.

A COMPLETE A.C. AMPLIFIER
This commercially available unit employs one CX-350 as the power tube. The second and third sets of binding posts at the top, reading from the left supply a.c. filament voltages for the set. This unit is from Silver-Marshall

Book Reviews

Lefax Radio Handbook—(Seventh Loose-Leaf Edition). Published by Lefax, Inc. Philadelphia, Pennsylvania. Subscription, $5.00 a year.

THIS Lefax Handbook is in the familiar form of a loose-leaf notebook about seven by five inches. The first chapter, "What Radio Does," is largely a summary of the various uses of radio communication, from the distribution of time signals to television, with some discussion of special devices like chain broadcasting. Next, under "Fundamental Principles of Radio" the behavior of direct and alternating currents, waves, and modulation methods is described. The following chapters are on "Elements of Receiving and Transmitting Apparatus," "Assembly of Receiving Sets," "Operation of Receiving Sets and Their Accessories," "Antennas." The next-to-the-last section contains conversion tables, definitions of radio terms, codes, formulas, tube characteristics, etc. A complete index is supplied. The material is gleaned from such journals as the *Proceedings of the Institute of Radio Engineers*, the *Bell System Technical Journal*, Bureau of Standards publications, Radio Broadcast, manufacturers' bulletins, etc. It is clearly abstracted and an extensive survey of practical radio engineering material is crowded into this loose-leaf book. The editor is Dr. J. H. Dellinger, Chief of the Radio Laboratory of the Bureau of Standards. The system is based on the issuance of sixteen sheets a month, ready to be inserted in the binder. Obviously the rate of progress of radio technology is such as to require some such scheme as a supplement to scientific textbooks which can appear only in widely separated editions.

Radio Engineering Principles, by Henri Lauer and Harry L. Brown. Second Edition, January, 1928. McGraw-Hill Book Co., Inc. 301 pages. $3.50.

THIS text, first issued in 1919, follows Morecroft into a second edition. Unfortunately the death of one of the authors, Harry L. Brown, occurred just before the volume appeared. With Mr. Lauer, he was able to complete a creditable piece of work before he died. The book is less extensive than Morecroft's, but it is excellent for those whose requirements are satisfied with a shorter and less expensive text. The treatment is based on the electron conception of matter, with only moderate resort to mathematics and no recourse to mechanical analogies, with which, frequently, the student is even less familiar than with the radio theory he wants to learn. The book, as the title indicates, is concerned with principles rather than with concrete apparatus. It begins with a consideration of the underlying electrical theory, the properties of oscillatory circuits, antenna systems and radiation, proceeds to a description of damped and continuous wave telegraphy, devotes four long chapters to vacuum-tube theory, and ends with chapters on radio telephony and miscellaneous applications of radio. The principal additions to the first edition are in the chapters on three-electrode tubes. Numerous special topics, such as aircraft radio compass work, the mathematical theory of the push-pull amplifier and frequency doubler, the theory of the balanced modulator, piezo-electric resonators and oscillators, are adequately treated. The book is a very scholarly presentation. Pages 69–73 contain one of the few adequate descriptions of the wave antenna to be found in radio texts. The references to little known articles, especially foreign sources, are alone sufficient to warrant inclusion of the second edition in every radio engineer's library.

A Popular Guide To Radio, by B. Francis Dashiell, The Williams and Wilkins Company, Baltimore, 289 pages, $3.50.

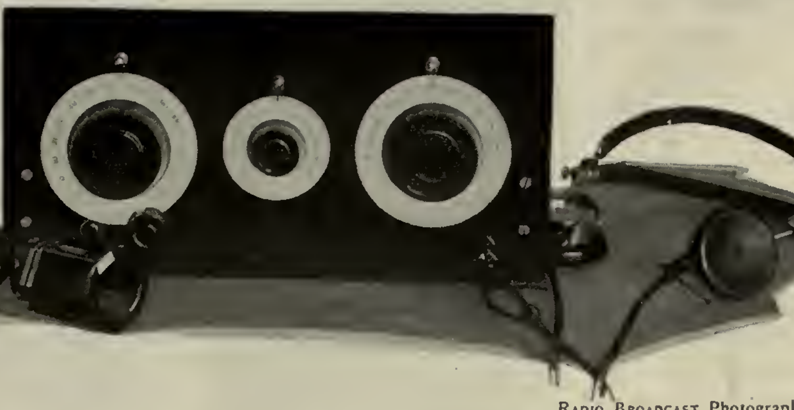
THIS book is written for the non-technical reader, according to the publishers. The author is only incidentally a radio man; his regular employment is in the Weather Bureau at Washington. The job of presenting the principles and mechanism of radio appears to this reviewer, who is a professional radio man and technically inclined, to have been competently done. Apparently Mr. Dashiell knows quite as much about the art as if he had lived in it all his life. But it is not clear, and this book does not make it clearer, just how a technical subject can be expounded to a non-technical audience. In so far as *A Popular Guide to Radio* elucidates and instructs, it is moderately but quite definitely technical. It is not made less technical by the insertion of a frontpiece showing Carlin and McNamee broadcasting a football game. If "non-technical" means free from mathematics, then the book is non-technical, true enough. But this merely results in passages like the following description of "Impedance in an Alternating Current Circuit": "A circuit may have inductance and capacity in addition to its natural electrical resistance when an alternating current is flowing. When this combined reactance and natural resistance operates to obstruct the flow of an alternating current it is known as the *impedance*. However, as inductive and capacitive reactances are the reverse of each other, the *total* reactance of a circuit is the difference between the two reactances measured in ohms and giving the impedance designation to the predominating reactance. The electrical resistance in ohms cannot be added to this total reactance to obtain the impedance. Graphically, they should be combined as straight lines in proportionate lengths. Assuming them as two forces acting together at right angles, their *resultant* is the impedance." This sort of writing is neither wholly accurate, readily comprehensible, nor compact. Its somewhat puffy and labored quality arises from the fact that it is the wrong way of doing the thing. And incidentally impedance is just as natural as resistance.

When Mr. Dashiell does not attempt the impossible he turns out a creditable piece of work.

There is a lot of sound, up-to-date information, with a few platitudes intermingled, and here and there a debatable statement, such as that on page 170 about the neutrodyne circuit, where the names of Hogan, Hazeltine, and Atwater Kent are mentioned, and not a word about Rice and Alexanderson. The photographs are well-chosen and the figures nicely drawn. After reading it one is left with the impression that this is a worthy book, but exactly for whom was it written?

—Carl Dreher.

The "Cornet" Multiwave Receiver



RADIO BROADCAST Photograph

By W. H. WENSTROM

Lieut., Signal Corps, U. S. A.

SOME of the most fascinating fields of radio lie outside that narrow band in which the broadcasting stations do battle. Voice and music from Europe, code from tossing ships or lonely airplanes, faint signals from amateurs at the antipodes or explorers in arctic cold and equatorial heat—all these are echoing along the lanes of the ether. To hear them we must have a receiver that is simple, reliable, accessible, efficient and flexible. As the Navy recently applied the name "Cornet" to an unusually flexible transmitter, so this receiver, able to shift rapidly from one frequency to another—to play a variety of tunes—is also called "Cornet."

The general design is apparent from the circuit diagram, Fig. 1, and the photographs. For simplicity we go back to that venerable amateur mainstay, a capacitatively controlled regenerative detector with one stage of audio; and we avoid tuned radio-frequency and screen-grid tube arrangements. On the front panel are one main and two auxilliary controls, while two adjusting controls are on the sub-panel.

Reliability is secured by using the best parts that we can buy. We avoid the pitfalls of some poorly made pig-tail condensers, noisy grid leaks and the like. Each radio part must meet two exacting standards—the electrical and the mechanical.

Accessibility is often neglected in radio design. The best set in the world will occasionally develop trouble, which must be located and remedied at once. This set is accessible because of sub-panel construction and general openness of design.

In pure efficiency, the regenerative detector has never yet been equalled. Unusual features of this set include a micro-vernier condenser of about 3.0-mmfd. maximum capacity and a grid biasing potentiometer which controls the sensitiveness, selectivity and oscillating characteristics of the detector tube. All three tuning condensers are mounted directly against a panel backed with aluminum which in turn is connected through the sub-panel brackets to ground; so that body capacity, as found in the usual short-wave receiver, simply does not exist.

Above all, the receiver is flexible. The Silver-Marshall plug-in coil system is used on account of its electrical efficiency, convenience, and compactness. The set is primarily designed to cover, with four coils, the range from 14 to 200 meters. This range is obtained by using a tuning condenser somewhat larger than usually recommended by Silver-Marshal. Additional bands can be covered, as desired, by extra coils.

CONSTRUCTIONAL DETAILS

THE arrangement of parts is shown in the photographs. First, drill the metal and insulating front panels; then assemble the front panels, the sub-panel brackets, and the sub-panel. All are bolted together with small nickeled machine screws. For best appearance, the front panel should slope back about 15 degrees from the vertical.

Three Cardwell condensers, with their associated General Radio dials, are mounted on the front panels. The right condenser, viewed from front panel, is of 0.00025-mfd. maximum capacity, and may be either the old, flat-plate type, which sells very cheaply in many stores, or the new taper-plate type. The left condenser should have a maximum capacity of about 0.000165 mfd.. This is obtained from an old type 0.00025 by removing two rotor and two stator plates, leaving four rotors and three stators. If the old type 0.00025 cannot be secured, the new taper-plate 0.00015 may be used, though with this latter condenser, minute uncovered frequency bands will appear between the coil ranges. Of course, the coils may be slightly redesigned to cover these breaks; or the standard S-M coils may be used, with some loss of tuning range. The center condenser is a Cardwell "Balancet" of the smallest size, with all plates removed except the back stator and the front rotor. The "phones" jack is placed at the lower right corner of the front panel, insulated from the metal by a bushing of bakelite, hard rubber or fibre. Because the set must often be switched on and off without jarring it or disturbing the wavelength setting, an external knife switch is used by the writer rather than a filament switch on the panel.

THE set described here by Lieut. Wenstrom has two features unusual in receivers designed to cover the high frequencies: (a), *a potentiometer across the A battery to adjust the bias voltage on the gird of the detector so that the best operating point may be found; and* (b), *a small vernier condenser across the main tuning condenser to enable the operator to tune very closely to a given frequency, or to follow a fading signal with greater ease. On test in the Laboratory, this receiver worked very well,* 5 SW *at Chelmsford, England, being heard at* 6 *p. m. E. S. T., without difficulty. The biasing potentiometer adds much to the sensitivity of this set. It is common amateur practice to use a high-ratio transformer, working out of the detector into the first audio tube. Lieut. Wenstrom has used a low ratio transformer which provides better reproduction when the set is used for receiving short-wave broadcast transmissions. A vernier dial with a greater reduction ratio than the one employed—such as the Karas—might make tuning somewhat easier, perhaps even obviating the necessity for the auxiliary tuning condenser.*

—THE EDITOR.

On the upper side of the sub-panel are mounted the coil socket, the two tube sockets, two filament ballasts, two grid leaks and knobs for the antenna condenser and the potentiometer. On its lower side are the potentiometer, the audio transformer, the r.f. choke, the grid condenser, and the antenna coupling condenser, for which a Silver-Marshall midget is chosen because of its low minimum capacity. The binding posts are set into the back edge of the sub-panel. The amplifier grid leak is clipped in when wanted for phone work; the glass casing of the detector grid leak should be washed free of paper and glue.

Wiring is best done in definite steps. The filament circuit is first wired and tested. Then come the other circuits in natural order: antenna-ground, detector grid, detector plate, amplifier grid, and amplifier plate. Grid leads, of course, are reasonably short, and all leads are fairly straight without sharp angles. Though No. 14 wire is used in places for rigidity, most of the wiring is done with solid, rubber covered wire of about No. 20 size, known in telephone parlance as "pothead" wire. It is plainly absurd to insist on large wire leads in series with coils, high resistances and the like. Acme Celatsite is also quite satisfactory and convenient.

The four plug-in coils are those supplied in the Silver-Marshall No. 117 short-wave set, rewound with No. 26 enameled copper wire except as otherwise indicated. They are completely described in the coil table. Three optional extra coils are also listed.

The detector tube is preferably a Ceco type "H," though it may be any good make of high-mu tube, or even one of the 201-A type. [The 201-A is satisfactory as a detector in this circuit, of course. If the Ceco type H, or other special detector tubes, or even a standard high-mu tube is used, the "gain" will increase. However, in the latter case, quality may be impaired to some extent when this set is used for headphone reception.—*Editor.*] The amplifier tube is a 201-A.

COIL TABLE

COILS for the first four bands listed below are those supplied in the Silver-Marshall No. 117 short-wave coil set, rewound with No. 26 enameled copper wire, except as otherwise indicated in the last column.

Band	Coil Range	Grid Turns	Tickler Turns	Remarks
20 m.	14–28 m.	3	3	No. 24 wire, with triple (the standard S-M) spacing
40 m.	26–52 m.	6	5	Grid 1 less; tickler 2 less than S-M standard
80 m.	51–110 m.	15	8	Grid 3 more; tickler 2 less.
160 m.	100–200 m.	36	16	Grid, 10 more; tickler same.
Shortest wave	10–21 m.	2	3	No. 24 wire; quadruple spacing.
Ship waves	550–1100 m.	Standard S-M No. 111-D		
Long wave	1100–2000 m. approx.	Standard S-M No. 111-E		

No cabinet is included in the plans, as a small writing desk serves the purpose, and the builder may have his own especial preferences anyhow.

OPERATION

TO place the set in operation, connect the 6-volt filament leads, see that the tubes light, and then connect the 45-volt B battery. Next,

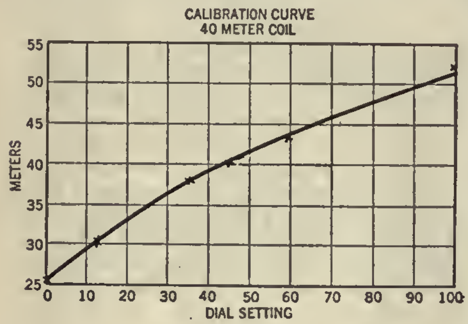


FIG. 2
Calibration curve of the 40-meter coil and condenser combination used in this set. Slight electrical differences in parts used by constructors may make their calibration different from this

place one of the coils, say the 40-meter one, in the coil socket. With the left-hand condenser set at any reading, increasing the right-hand condenser should put the set into oscillation with a weakly audible "plop." The potentiometer is adjusted to minimize this "plop" so that the set goes smoothly into and out of oscillation. In general, the potentiometer arm is turned toward the positive side of the circuit for phone work and slightly toward the negative side for code reception. As the left dial is moved to a higher reading, a correspondingly higher reading on the right dial will usually be necessary to produce oscillation. If the r.f. choke is doing its work, there should be no "dead spots" in the tuning range. At any wavelength setting of the left dial, the most sensitive right dial setting for phone is just below or at the oscillating point; for code, just above it.

With these preliminary tests completed, the set is connected to the ground and to the antenna, a single wire anywhere from 20 up to 750 feet in length. [A small indoor antenna with this set in most locations will probably serve very well for all purposes..—*Editor*.] The 40-meter coil being in place, signals should be heard as the left dial is moved over its entire range, for this band is busy at any hour of the day or night. If any "dead spots" now occur, blame them on the antenna, and decrease the antenna coupling condenser to the point where they are not troublesome. This antenna condenser is always set at the maximum capacity which will not interfere with the convenient operation of the oscillation control. After a signal has been tuned-in with the left dial and brought to full strength with the right one, apply the finishing refinement of tuning with the center dial and its diminutive condenser. This control is so fine that a single beat note spreads over 5 to 10 degrees, and the "zero beat" for phone reception is easily produced.

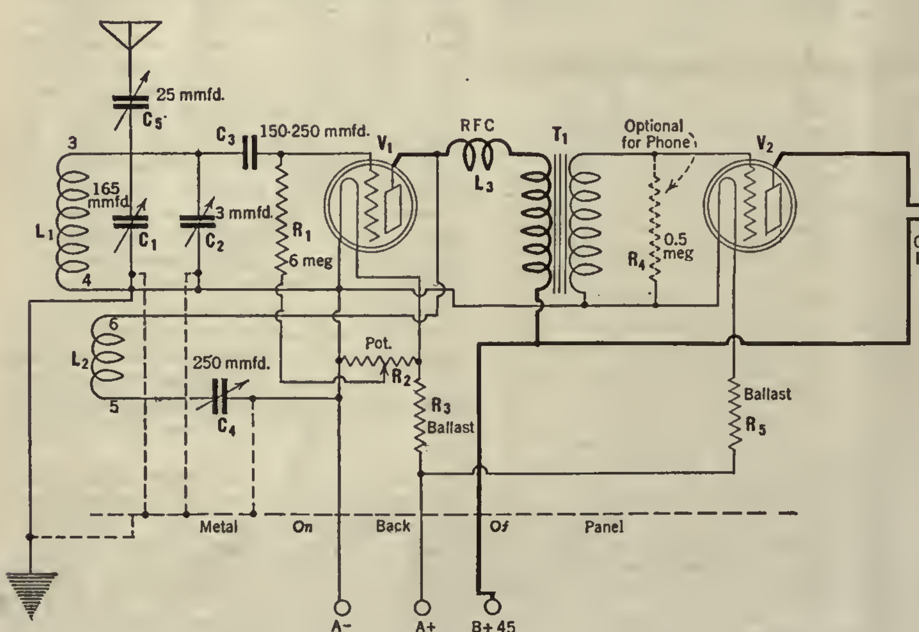


FIG. 1
Circuit diagram of Lieut. Wenstrom's receiver

CALIBRATION

FOR maximum usefulness all coils should be carefully calibrated. The data, including the settings of the left dial for various wavelengths, may be plotted as a graph, which is scientific and thorough (see Fig. 2); or they may be listed in a table, which is more convenient to read. Such a table for the 40-meter coil employed by the writer is: 0–26*m*., 13–30*m*., 36–37.5*m*., 45–40*m*., 59–43*m*., 100–52*m*. While this table is approximately correct for the set here pictured, changes in detector tube, wiring and variations in coils used by those who duplicate this set, or other circuit constants would make it practically useless for another. Each set must be calibrated individually.

First, a wavemeter must be bought, borrowed or made. Then, the left receiver dial is set at some convenient reading (say O), the antenna condenser is set to minimum, the vernier to 50, and the right dial to two points above oscillation. Place the wavemeter coil in what would be a

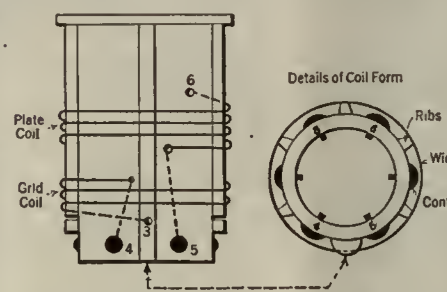


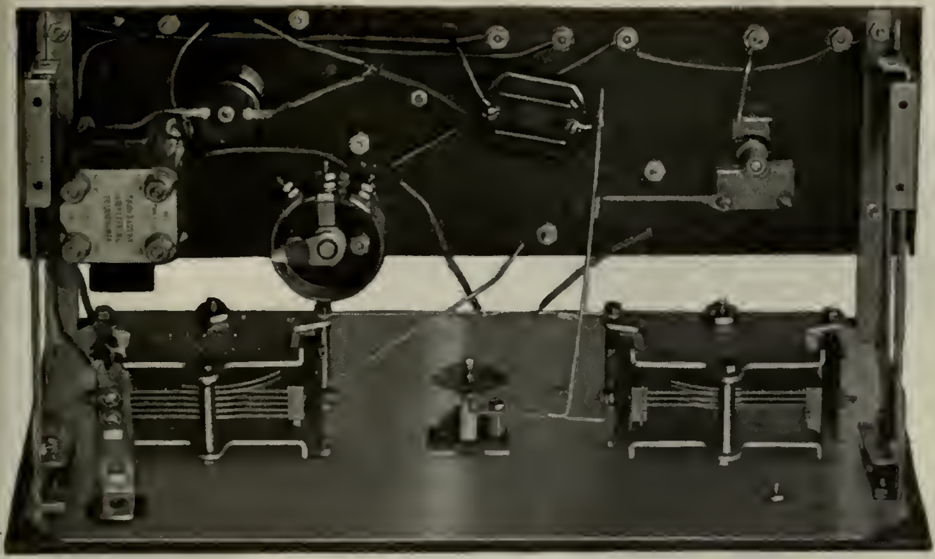
FIG. 3
General instructions on altering the coil form for the 20-, 40-, 80-, 160- and 10-meter bands. (See the coil table on this page)

prolongation of the set coil, and rotate the wavemeter dial slowly. Two "plops" are heard, one as the set goes out of oscillation and another as it goes back into it. Now move the wavemeter a little farther away, and repeat the performance until the two "plops" are practically one. Or note the point midway between the two "plops." This point on the wavemeter scale is the wavelength to which the receiver is tuned. The left dial is now moved to a new setting and everything is repeated. All the coils are calibrated in the same way. If you wish to find the receiver dial reading for any particular wavelength, set it on the wavemeter and rotate the receiver dial.

A wavemeter is simple enough to make. The basic circuit consists essentially in a coil and a variable condenser. The homemade product must be calibrated from a standard one. By checking both against the receiver, data is secured for a homemade wavemeter curve similar to the curve of Fig. 2. Of course it is possible to calibrate one's receiver by picking up signals from well-known stations. For example the amateur 40-meter band is bounded by NAA at about 37.4 meters at one end and by WIZ at 43 meters at the other. Standard frequency signals are sent out at regular intervals by WWV, the Bureau of Standards station, (see page 84) and others.

WHERE TO FIND THE STATIONS

WE NEED have no illusions about the quality of short-wave broadcasting, nor any fear that it will replace the present system of allocation of stations in the 1500–550-kc. band. Fading is usually quite severe, and the signal strength of distant stations varies widely from day to day. In America, WGY on 21.9 and 32.77 meters and KDKA on 25 and 62 meters transmit



RADIO BROADCAST Photograph

THE CORNET MULTIWAVE RECEIVER

the regular programs of their standard-wave broadcast plants. Their signals have world-wide range, and quality dependent on the atmospheric and Heaviside layer conditions. In England, 5 SW at Chelmsford carries the regular London programs on 24 meters, and is heard any weekday afternoon up to 7:00 p. m. E. S. T. Reception of this station is really good perhaps one or two days a week. The signal of PCJJ at Eindhoven, Holland, is weaker and more variable than that of 5 SW. It comes through at present late Tuesday, Thursday, and Saturday afternoons (Eastern time). So far, these two have been the only foreigners regularly heard, and their programs have appealed chiefly by their novelty. Perhaps within a few years most important nations will have high power, short-wave telephone transmitters, and fading will be minimized by separated, synchronized transmitters or some such scheme. Then international broadcasting will truly begin, and this receiver will be able to choose its programs between five continents.

For one who reads code the pleasures of this receiver, and of all radio, are greatly extended. NAA at Washington, on approximately 24.9, 37.4 and 74.8 meters, broadcasts weather at 8.15 and 10:30 a. m. and p. m.; time at 12:00 noon and 10:00 p. m.; and press at 1.30 a. m., E. S. T. Station NPG at San Francisco, on 36 and 72 meters, sends weather at 6:15 and 7:30 a. m. and p. m., P. S. T. To keep up to date on these schedules, one must consult the weekly radio sections of large newspapers. [A list of Navy transmissions appeared in this magazine for May, 1928.—*Editor.*] The biggest nuisance in the short-wave spectrum is the harmonics of long wave broadcasting stations, which delude the listener in this short-wave section of the band into thinking he hears something new.

Many important exploring expeditions transmit code. Most of them favor the waves around 30 meters. This summer there will be at least one expedition near the North Pole, one near the South Pole, plenty of transocean flights, and at least one round-the-world dirigible flight. Some far distant amateurs come in from 18 to 24 meters during many of the daylight hours, though most of these experimenters use the 40-meter band. In this region, Europeans between 43 and 47 meters, just above the United States band, begin to be heard about an hour or two before sunset. Before sunrise signals from the Australians and New Zealanders come through around 33 meters. There are some United States amateur telephone stations between 84 and 85 meters.

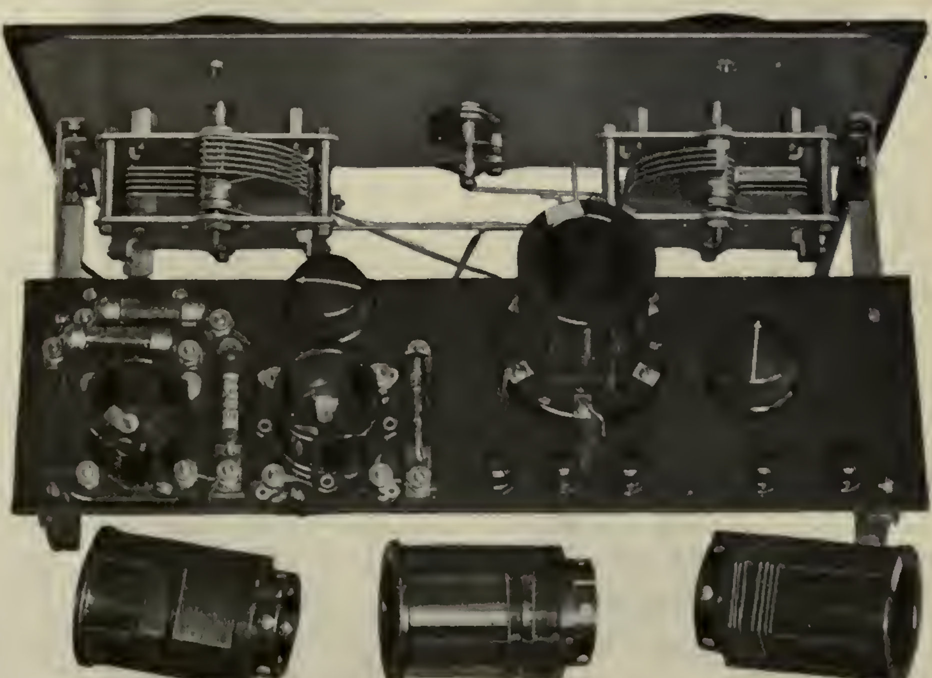
Six hundred meters is the international marine calling wave. Rapid dots and dashes from ship sparks are always audible near the seacoast. On this wave, too, sounds at times the staccato SOS for which broadcasting stations shut down. Copying signals from a ship in distress and the vessels going to her assistance is the most exciting thing in radio. Of course it is in no sense a pleasure; the lesson of Robert Louis Stevenson's *Merry Men* is plain. For actual message handling, ships use waves around 700 and 900 meters. On 1000 meters in foggy weather, the coastal radio beacons flash their distinctive groups. Radio compass bearings are given on 800 meters. For data on the coils which cover all the bands discussed in this article, see the table on page 78.

This "Cornet" multiwave set opens the door to reception interesting and unlimited, or limited only by the skill and patience of the operator. And what more could he ask?

THE PARTS WHICH WERE USED

THE following list of parts gives the apparatus used in the writer's receiver. Naturally, other parts, electrically and mechanically similar may be used. Coils and condensers mentioned here are of well-known manufacture and have been altered in ways indicated in the text.

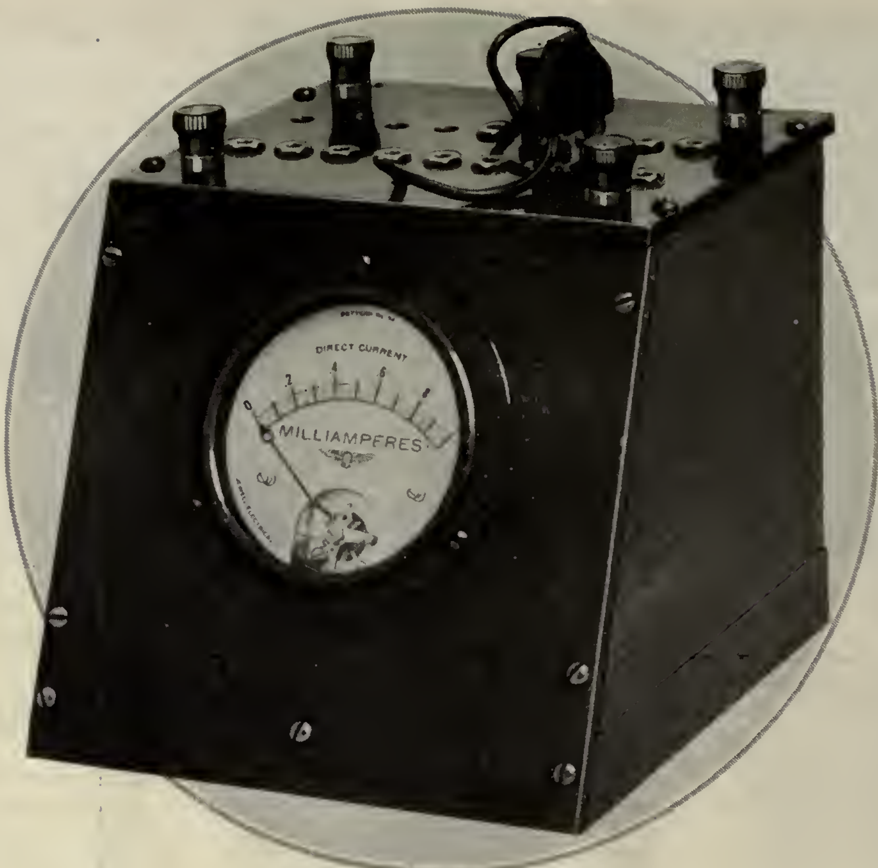
C_1	Cardwell type 141-B 250-mmfd. variable condenser, (revised as indicated in the text)
C_2	Cardwell Balancet 5-mmfd. (approx.) variable condenser
C_3	Sangamo 150-mmfd. fixed condenser
C_4	Cardwell type 141-B 250-mmfd. variable condenser
C_5	Silver-Marshall type 340 midget condenser
L_1, L_2	Coils wound on Silver-Marshall forms (as described in text)
L_3	Silver-Marshall Type 275 R.F. choke
R_1	Tobe Tipon 6-megohm grid leak
R_2	General Radio type 301, 200-ohm potentiometer
R_3	Daven ¼-ampere filament ballasts with mountings
R_4	Tobe Tipon 0.5 megohm resistance (optional, see text)
T_1	Thordarson small type 2:1 audio transformer
1	Silver-Marshall coil socket type 515
1	Benjamin navy spring type socket
1	Hoosick Falls navy plain type socket
2	Grid leak mountings
2	Knobs, Kurz-Kasch, 1½-inch
1	General Radio type 303 4-inch vernier dial
1	General Radio type 317 4-inch plain dial
1	General Radio type 310 2¾-inch plain dial
5	Eby plain binding posts
1	Pacent open circuit jack
1	Insulating bushing for jack
1	panel 7" x 14", hard rubber or bakelite
1	back panel, 7" x 14", aluminum
1	Sub-panel, 4" x 14", hard rubber or bakelite
2	Benjamin adjustable sub-panel brackets



RADIO BROADCAST Photograph

HOW THE MULTIWAVE SET LOOKS FROM THE TOP

Four of the coils used are shown with their convenient adhesive tape labels



AN INSTRUMENT OF WIDE USE TO EVERY RADIO EXPERIMENTER

With an inexpensive milliammeter arranged as described in this article, a portable and very useful measuring set can be made. The set will measure practically all of the common d.c. voltages and currents up to 5 amperes and 1000 volts. It is especially useful in testing B power units. The crystal detector circuit makes this unit useful as an r.f. resonance indicator in transmitter circuits

From Milliammeter to Multi-meter

G. F. Lampkin

PERHAPS one of the fundamental reasons why electrical science has grown so tremendously in its comparatively short life span is the ease and accuracy with which electrical measurements can be made. An ability to determine accurately the magnitudes and relations of the quantities involved in any work naturally leads to intelligent interpretation and utilization of those quantities. Applying the last statement to the radio worker, an ability to measure the B-battery voltage at 17 volts per 22-volt block is much more conducive to results than wondering if low B batteries are spoiling the reception; and plugging-in to measure the plate current of a tube can be made to save many minutes, if that particular tube has gone dead.

It is surprisingly simple to take a low-range milliammeter and make an almost universal measuring instrument of it. The instrument can be made to measure the whole gamut of d.c. radio voltages, from the voltage of a dry cell on up through the various A, B, and C voltages to those used for plate supply in transmission work. Starting with a meter of one milliampere full-scale deflection, the current range can be run up as high as desired; and then the meter can be used for indicating a few other quantities on the side. The extension of the milliammeter range to read both voltages and currents of various magnitudes is accomplished by means of what are known as multipliers and shunts.

Suppose two resistors are put in parallel in a circuit; the current will naturally divide, part going through one resistor and the rest through the other. An idea as to how the current divides through the two paths can be had if the values of the two resistors, R_1 and R_2, are known. The current, I_2, in resistor R_2 is equal to:

$$\frac{R_1}{R_1 + R_2} \times \text{Total Current}$$

And similarly, the portion I_1 in the path R_1 is equal to:

$$\frac{R_2}{R_1 + R_2} \text{ x Total Current}$$

The idea of the shunt is to bypass a part of the total current around the milliammeter, and let only enough current go through the latter to give full-scale deflection when the total current to be measured is flowing. If the total current is less than that required to give full-scale deflection, with a given shunt, the meter reading will be less in the same proportion. By properly choosing the resistance of the shunt, the meter can be used to read any magnitude of total current. If the shunt resistance is very low, the meter can be used to read large total currents; or, conversely, if the shunt resistance is high, small currents can be measured. With no shunt, the meter of course indicates the current as shown by its scale. Another consideration in choosing the shunt, besides its resistance, is its physical size. The shunt must be of large enough carrying capacity that it does not get hot when passing its part of the current. If it should get hot, its resistance would change and destroy the accuracy of the readings.

To use the milliammeter as a voltmeter requires a multiplier. The latter is simply a resistance that is connected in series with the meter. Suppose the milliammeter, with a current scale of 0-1 milliamperes, has a resistance of 3 ohms. With full-scale deflection, the voltage drop across the meter is 0.001 amperes times 3 ohms, or 0.003 volts. Another way of stating the requirement for full-scale deflection of this meter is, therefore, to say that 0.003 volts must be impressed across it. When the multiplier is placed in series with the meter, its resistance causes a voltage drop, and leaves remaining a small value of voltage to operate the meter. By choosing the right values of series resistances, the meter can be used to measure a wide range of total voltages. For a meter resistance of R_1 ohms and a multiplier resistance of R_2 ohms, the voltage on the milliammeter will be:

$$\frac{R_1}{R_1 + R_2} \text{ x Total Voltage.}$$

The economy resulting from the use of shunts and multipliers is obvious. A 0-1 Jewell d.c. milliammeter can be had for $7.50 list. With this one meter as an indicator, as many shunts and multipliers as desired can be made, at a fraction of the meter cost, and each shunt, or multiplier, will extend the use of the meter.

The meter shown in the photographs is designed to cover pretty well the field of d.c. measurements in radio. In addition, it utilizes a fixed crystal detector to yield an instrument somewhat similar to a thermo-galvanometer. While it cannot, in the latter rôle, be calibrated to read actual current values, still it is extremely useful in radio- and audio-frequency measurements, for showing relative values, or for indicating re-

sonance or null settings. The plug-in system which is used makes it a matter of seconds to change from one range to another, or from voltmeter to ammeter, or a.c. indicator. In the particular instrument shown, the layout provides for five current ranges: 0-1 mA., 0-10 mA., 0-100 mA., 0-1 Amp., and 0-5 Amps. The voltage ranges are 0-10, 0-100, and 0-1000 volts. The a.c. indicator requires approximately 5 mA. a.c. for full-scale reading. Fig. 1 gives the panel and cabinet layouts.

In Fig. 2 is given the diagram of connections. The double plug is simple to construct. The material for it is cut to shape as shown in Fig. 1. and then two General Radio type 274P contact plugs are screwed into the two threaded 6/32 slots. The receptacles for the double plug consist of General Radio type 274J jacks.

Only one connection to the double plug is needed when the instrument is used as a voltmeter or a.c. indicator, so the rear sockets for these connections are left blank on the panel top. Thus a total of fourteen 274J jacks will be necessary. For appearance's sake, however, the blank holes might be hidden by using four more jacks, to which no connections are made. The negative binding post is made common for all the functions of the meter. It is brought out at both sides of the panel to facilitate connections. The milliammeter is placed in the negative side of the circuit so that it will be at ground potential when the device is used as a voltmeter. The positive binding posts are separated for the three functions of the meter. This makes for safety in that it lessens the chance of using the ammeter connection when trying to measure a voltage. It also allows connecting the device in the circuit to measure both voltage and current, and doing one or the other by changing only the plug. The end of the carborundum detector marked "A" by the manufacturer goes to the positive binding post. The 0.0005-mfd. condenser is shunted across the meter to protect it from radio-frequency currents; its use is not an absolute necessity, however. The supports for the shunts, multipliers, and detector are made of bus wire. The common rear support for the three multipliers is made of sheet copper or tin. The multipliers used are Tobe Veritas 5-watt resistors. The power expended in the resistor for the higest range is 1000 volts times 0.001 amperes, or only 1 watt, which is sufficiently low to avoid heating the multiplier.

The table of Fig. 2 shows the shunts that are used for the different ranges. For the lower ranges, *i.e.*, 10 and 100 milliamperes, No. 32 tinned hair wire was obtained from the hardware store. The 10-milliampere shunt is so long that it must be wound on a form, the dimensions of which are given in Fig. 1. The other shunts are short enough to be suspended between their bus-wire supports. The smallest sizes of copper wire consistent with freedom from heating effects are used as shunts for the higher ranges. Smaller sizes than these should not be used; should larger sizes be used, the lengths given in the table must be increased. The lengths specified may be slightly on the long side, in which case they should be clipped when calibrating. All the connections in the instrument should be soldered.

As shown in the photograph, the connections between the top panel and the meter are flexible; thus the top panel can be turned over to an easily accessible position when adjusting the shunts. It is wise to mark the sockets plainly with the appropriate data—100 Volts, 1 Ampere, etc.

THE FINISHED INSTRUMENT—INSIDE

CALIBRATION

THE calibration of the meter is the most important part of the job. The straightforward and accurate method is to compare the meter directly with standard instruments. It should be possible for the experimenter to obtain the use of voltmeters and ammeters from a friend, a radio dealer, radio laboratory, educational laboratory, power company, or other such source. But, failing in these, it is still possible to obtain reasonably accurate calibrations. In any case, the readings of the meter should not be relied upon for greater accuracy than two or three per cent.

To compare the voltmeter ranges of the device directly with a standard voltmeter, the two instruments should be put in parallel and connected to the voltage source, as in Fig. 3. The source may consist of a storage battery or dry cells, for the ten-volt range, and a bank of B batteries, or a B device for the higher ranges. Both meters should be connected when the readings are made, and the latter should be taken nearly simultaneously. It is not necessary to take more than three or four points uniformly spaced along the scale. If only one or two readings are possible, these should be made near the top of the scale. On a piece of graph paper a scale from 0 to 10 should be drawn on the horizontal axis, to correspond to the meter scale. A scale from 0 to 1000 is drawn vertically to correspond to the readings of the standard instrument. When the calibration points for the 10-volt range are plotted, the vertical scale is assumed to run from 0 to 10, that is, the decimal point is placed by inspection, and the curve is labeled 0-10 volt range. The points for the 100- and 1000-volt ranges are treated similarly, so that the entire voltmeter calibration is on one sheet. The calibration curves are really straight lines running through the zero point. One accurate point is sufficient to determine the line, but more than one serves as a check. If all the points do not lie on the line, the latter should be made to run an average course through them. The calibration curves for the particular meter shown are given in Fig. 4. It must be borne in mind that these curves will fit no other meter.

The drawing of the calibration curves is necessitated by the inaccuracies of the resistance values of the multipliers. The 1-megohm multiplier should have yielded a full-scale range of 1000 volts, where in fact it gave only a range to 702 volts. In other words, its resistance is 702,000 ohms, and not 1,000,000 ohms. Incidentally, when using a 0-1 milliammeter as indicator, the number of thousands of ohms in the multiplier is equal to the full-scale range of the voltmeter; *i.e.*, a 1000-ohm resistor gives a 1-volt range, a 10,000-ohm resistor a 10-volt range, etc. The disadvantage of the inaccurate resistor is only that the calibration is not a multiple of 10. Once the

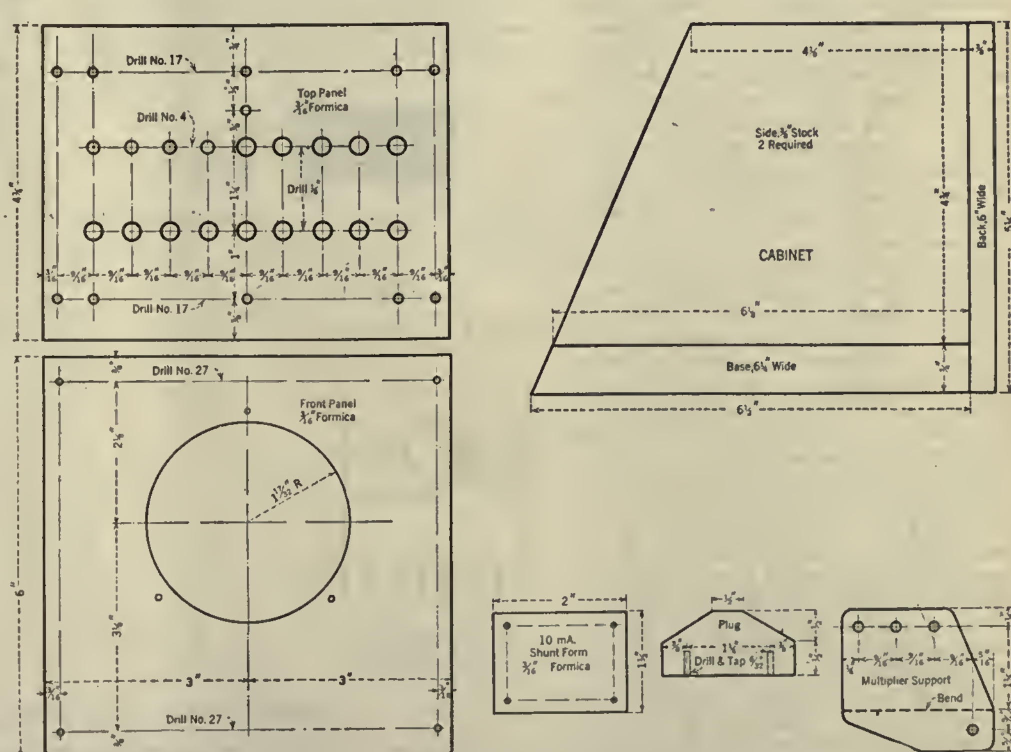
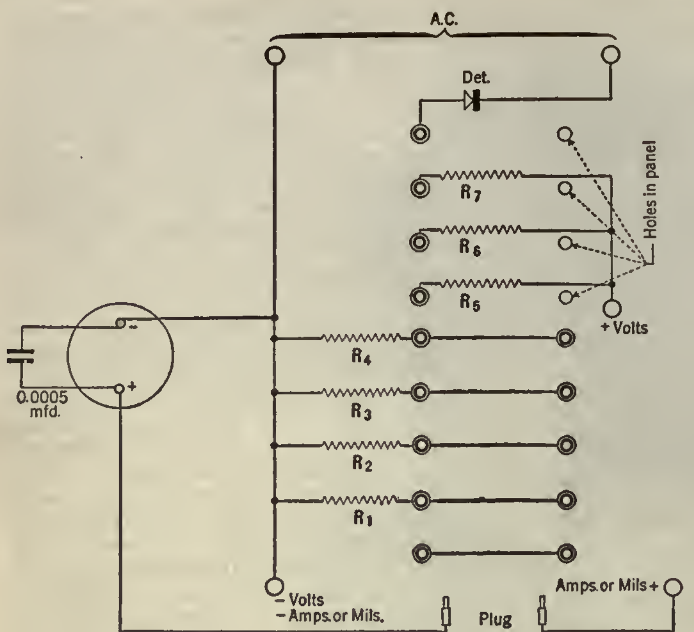


FIG. 1

Layout for panel and cabinet of the useful home tester described here. The photograph above shows the disposition of the shunts, meter, and fixed detector



SHUNTS

R_1 10 mA.	7½ Feet No. 32 Tinned Hair Wire	
R_2 100 mA.	4 Inches No. 32 " "	
R_3 1 Amp.	9 Inches No. 26 Copper Wire	
R_4 5 Amp.	7 Inches No. 20 " "	

MULTIPLIERS

R_5 10 Volts	Tobe Veritas	10,000 Ohm
R_6 100 Volts	" "	100,000 Ohm
R_7 1000 Volts	" "	1 Megohm

FIG. 2

Circuit connections and values of apparatus

instrument has been calibrated, readings may be taken as accurately as with correct-value resistors. If a standard voltmeter cannot be obtained, new dry cells and B batteries may be used as voltage standards. The voltage of a single dry cell should be taken as 1.58 volts, and that of a 22½- volt B block as 23.7 volts. Voltages of larger blocks should be taken in proportion—47.4 volts for a 45-volt block, and so on. Some half dozen calibration points should be taken, and the average curve drawn. The method will allow results of good accuracy. Of ten blocks whose voltages were measured, the maximum discrepancy from the voltage value given above was only 0.7 of a volt. Taking the average of several calibration points will tend to iron out any discrepancies.

In the case of the shunts, their lengths can be adjusted to make the scale come out even, so that no calibration curves are necessary. Although the milliammeter scale reads from 0, 0.2, 0.4, up to 1 milliampere, it must be remembered that with the shunt, say for 100 milliamperes, the scale is read 0, 20, 40, up to 100 milliamperes. It is another case of placing the decimal point. To calibrate the meter and shunts by direct comparison the meter is placed in series with the standard ammeter, as in Fig. 3. Suggested current sources and loads for the current calibrations are given. The load resistor is adjusted to give full-scale reading on the meter. If the reading on the standard ammeter is lower than the total current should be, first open the load circuit, then melt the solder and shorten the shunt. Or if the standard meter reads high, lengthen the shunt. Reclose the circuit and check again. A few trials will suffice to bring the reading to the dot. If the load circuit is not opened before loosening the shunt, the total current will pass through the meter and ruin it. Each shunt must be adjusted as above.

To calibrate the 10-milliampere shunt when no standard meter is available, place the meter in the circuit, plug in on the 1-milliampere range, and adjust the current to exactly 1 milliampere. Then plug-in on the 10-milliampere range; if the reading is high, shorten the shunt—or vice versa. Bring the reading to exactly 0.1 on the scale, corresponding to 1 milliampere on the 10-milliampere range. Finally, re-check the current on the lower range. For the 100-milliampere range, set the filament voltage at the socket terminals of a 199 type tube at 3 volts. The previously calibrated 10-volt voltmeter may be utilized. Then with rheostat setting unchanged, remove the voltmeter and place the 100-range milliammeter in series with the filament. Change the shunt till the meter reads 60 milliamperes. Again re-check the voltage. The same procedure may be followed in calibrating the 1- and 5-ampere scales, by using larger tubes. The 201-A tube gives 0.25 amperes at 5 volts, or the 112 or 171 tubes 0.50 amperes at the same filament voltage. For the higher loads, several tubes in parallel can be used, and the currents added up. The accuracy of this tube-load method is surprisingly high. Of four Radiotron UX-201-A tubes picked at random, the filament currents were 0.250, 0.250, 0.247, and 0.249 amperes at 5 volts. For a UX-112 it was 0.500 amperes, and for a UX-171 it was 0.493 amperes, at the same voltage.

The a.c. indicator is the part of the device that needs no calibration. If it were calibrated, the readings might be 50 per cent. off the next day. It is, however, a most convenient attachment. With a loop of wire connected to its terminals and coupled loosely to a radio-frequency circuit, it will show resonance points sharply. This function is of course applicable to wavemeters. In tuning up a crystal-controlled transmitter the indicator can be moved from circuit to circuit down the line, as the tuning progresses, and so may save several dollars and watts loss that would be occasioned by the use of radio-frequency ammeters in these circuits.

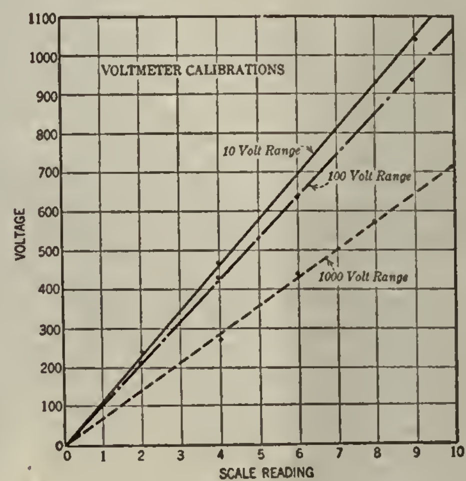


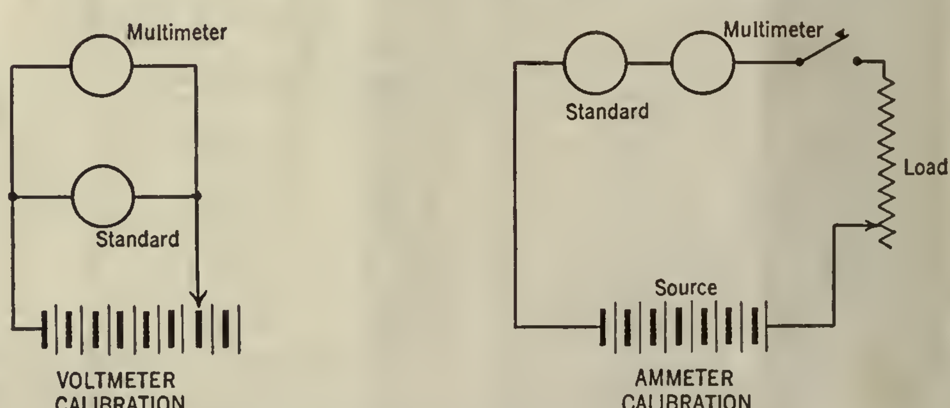
FIG. 4

Calibration curves made by the author for meter used in the original model. These calibrations are not standard, varying with apparatus used by the individual constructor

The complete meter shows up particularly well in the measurement of B device voltages. It is a high-resistance voltmeter—1000 ohms per volt. The current that it draws at the most does not act to give untrue voltage readings.

An enumeration of the single quantities that might be measured in radio work with the instrument would require considerable space, as would also detailing the connected experimental data that are possible of determination by its use.

GENERAL RADIO PLUGS AND JACKS USED

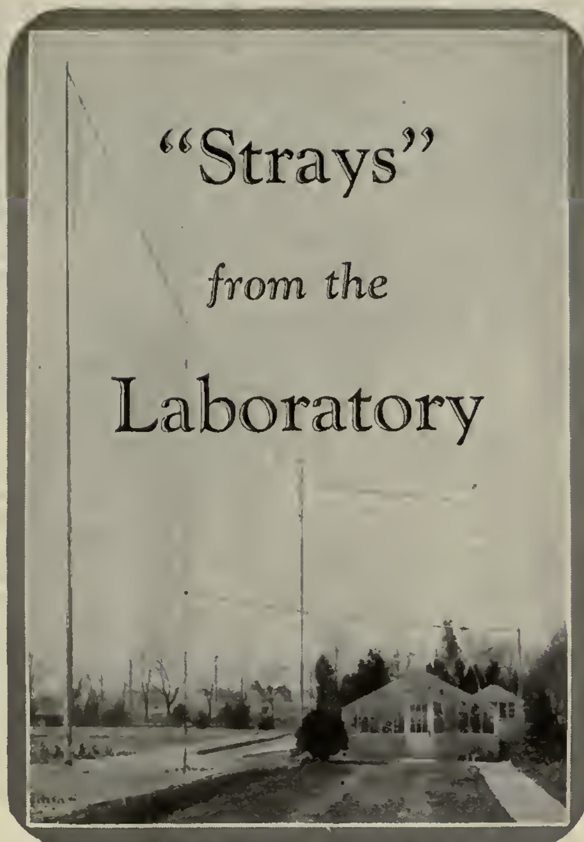


CURRENT CALIBRATION SOURCES AND LOADS:

10 mA.- Dry Cell, 400 - Ohm Potentiometer
100 mA.- 4.5-Volt Battery, 199-Tube Filament
1 Amp.- 6 - Volt Battery, 201-A, 171 Tube
5 Amp.- 6 - Volt Battery, 4-Ohm Rheostat

FIG. 3

How to calibrate the home-made meter set with a standard



"Strays" *from the* Laboratory

Output Transformer Characteristics

An output transformer connecting a loud speaker to a power tube serves two purposes: (*a*.). to keep the direct current flowing in the plate circuit of that tube from circulating through the windings of the loud speaker; (*b*). to correct any large impedance differences which may exist between the speaker and the tube. The user has a right to expect that the use of the transformer will not perform the tasks mentioned above at a loss in either power or fidelity.

The curve shown in Fig. 1 shows the frequency characteristic of the Pacent 1:1 output transformer. The upper curve represents the voltage across 5000 ohms when 15 volts were applied to the grid circuit of a 210 tube which was properly biased and taking about 20 milliamperes of plate current. The lower curve shows the same characteristic translated in TU. Anyone desiring to know the power delivered to the output load resistance may calculate it by dividing the voltage squared by the resistance. The extreme variation obtained in this manner is from 395 milliwatts at 60 cycles to 610 milliwatts at 2000 cycles, or less than 2 TU, which is quite good.

The loss in power occasioned by the use of a transformer instead of placing the loud speaker directly in the plate circuit of the tube may be calculated by dividing what one actually gets into the 5000 ohms by what would be obtained without the transformer. The power output of a tube working into its own impedance (in this case the 5000 ohms is sufficiently near that of the tube) is equal to

$$W_o = \frac{(\mu\ e_g)^2}{4\ R_p}$$

where

μ is the amplification factor of the tube
e_g is the input volts r.m.s.
R_p is the tube impedance

Using this formula, the power into 5000 ohms with 15 volts r.m.s. on the grid of the tube should be 720 milliwatts. Actually we get only 395 at 60 cycles and 610 at 2000 cycles. These are losses due the transformer of only 2.6 and 0.7 TU respectively.

High Powered Press Releases

Listen to this from the Radio World's Fair: "'The last frontier of radio resistance will bow before this final stroke of air-mastery, the automatic broadcast receiver,' said Rear Admiral Bradley Allen Fiske, leading inventor of the United States Navy for the past fifty years, as he declared himself as being much interested in the automatic broadcast receiver which was disclosed to the press during the past week by Harry N. Marvin, millionaire inventor of Rye, New York."

We hope Admiral Fiske didn't say any such thing because the inventor of the torpedo plane and the naval telescope sight which, again quoting from the release, "has been adopted by all the navies of the world and its use has been the main cause of the improvement in accuracy of modern naval gunnery," should know that automatic tuning has been in use many years in the navy, commercial, and amateur stations.

It is a simple matter to change the frequency to which a station, or a receiver, is tuned by pressing a button. How does the Admiral, or his press agent, think the frequency of WCC, that high-pressure coastal station of the Radiomarine Corporation at Chatham Massachusetts is changed? The operator is some miles away, and while there is an attendant at the transmitter, does he listen for a call on the 'phone, "Say buddy, how's for tuning-up WCC to 2000 meters?" We have been at Marion, Massachusetts, where the transmitter is and have seen the thing in operation. There is a click of a relay and the signals go out on 2100 meters, another click and the wavelength has been changed to 2000 meters, another click and the transmitter is turned off. No one has been near it for an hour or so.

No, the problem of turning on and off your receiver, or of changing its frequency setting, or regulating the volume control, all from a distance is not new. Neither is the idea that in the navy in time of war the frequency of a transmitter could be changed rapidly and at the will of the operator. Such schemes are as old as the apparatus itself and the business was reduced to practice many years ago.

If anyone wants to know how to tune his radio by pushing a button instead of whirling a knob, we'll tell him, and at the same time give him data on how to turn the thing off—in case of sopranos singing, for instance—or to change the volume. As a matter of fact, the interested reader may find an article on such matters in this issue. This scheme is at least old enough to have gone through the patent office, and in these days of radio inventions, this means something! Incidentally, Commander E. F. McDonald of the Zenith Radio Corporation states that his company has acquired Mr. Marvin's invention and that he, too, believes the last frontier of radio will bow etc., etc.

A.C. Troubles

The A. C. receiver seems to be causing dealers and service men no end of worry. A dealer in New Hampshire writes us typical complaint: "I. wish to state that the a.c. tube sets around this section are a decided failure. Fluctuating line voltages ruin tubes in a few weeks. I know of one individual that has had four sets of tubes this winter. I spent an hour explaining why a.c. tubes were no good to one prospective customer after which he agreed with me and thanked me. However, the next day he promptly went to my competitor and purchased an a. c. set."—

We should like to point out that the trouble is by no means altogether with the a.c. tube. For example, we know an editor of a nationally known magazine who owns a Radiola 17 receiver. He lives in a section of New York where line fluctuations are very severe, so severe in fact that he purchases a new 171 power tube and a.c. tubes, too, about every two months. The trouble here is patently not with the tubes, but with the bad voltage regulation.

Any tube operated at a temperature above normal will not last long. This means that a tube whose manufacturer states should be operated at 2.5 volts cannot be expected to lead a long or useful life if the voltage about half the time is 3.0 volts. Tubes operated from a.c. will last a long time if the voltage is normal or slightly below.

From time to time we hear rumors of voltage adjusting gadgets which are in process of development; units that plug between the house lighting socket and the receiver. Their duty is to keep the voltage down to some fixed figure. We predict a million dollar business for the first reasonably priced and successful equipment of this type.

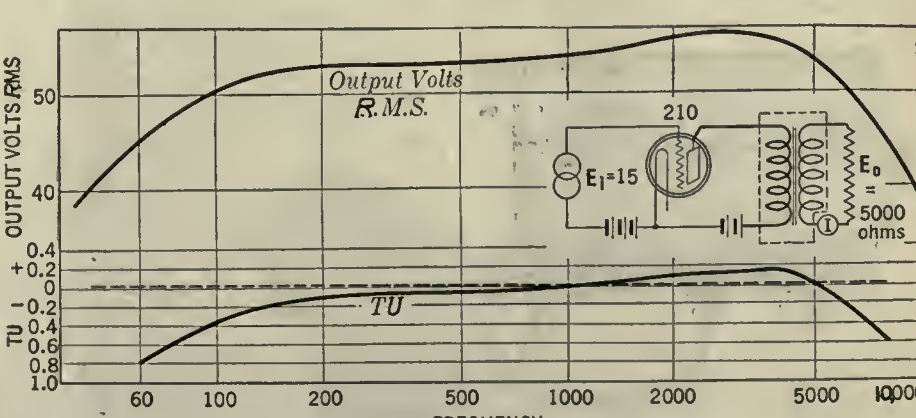


FIG. 1

May Standard Frequency Signals

STANDARD FREQUENCY signals from the Bureau of Standards have been used by amateurs, laboratories and experimenters for several years. These signals are sent out about the 20th of each month and begin at 10:00 P. M. E. S. T. On May 21, signals will be sent on frequencies of 650 to 1500 kc. and should serve as calibrating signals for wavemeters and oscillators working in the broadcast range of frequencies. The signals begin at 10:00 and continue until 11:32 P. M. They consist of slightly modulated c.w. telegraph and take place as follows: at 10:00 a general call will be sent consisting of the statement of the frequency, the call letters of the Bureau station, WWV, then a series of very long dashes and call signals on the stated frequency, then the statement of the frequency transmitted and the next frequency. These signals require about 8 minutes, and are repeated on the next frequency after a lapse of four minutes during which the transmitter is adjusted.

Anyone within 500 to 1000 miles of Washington, D. C. should be able to use the signals provided he has a receiver in which the detector can be made to oscillate, a Roberts or Lab. Circuit, for example. The receiver should be adjusted to the approximate frequency, the detector oscillating, with a pair of receivers in the output of the amplifier which may be one or two stages. At the proper time, indicated below, the receiver should be adjusted until WWV's signals are heard beating with the oscillations of the local detector circuit. This circuit should then be adjusted to zero beat with WWV, and a wavemeter, preferably an oscillating tube attached to a coil and condenser, is tuned also to zero beat. The wavemeter and the receiver and WWV are then all on the same frequency. A record should be kept of the frequency and the setting of the wavemeter condenser as well as that of the receiver in case it is desired to calibrate the receiver. The schedule follows:

E. S. T. MAY 21	FREQUENCY	WAVELENGTH
10:00—10:08 P. M.	650 kc.	462 metters
10:12—10:20	750 "	400 "
10:24—10:32	850 "	353 "
10:36—10:44	950 "	316 "
10:48—10:56	1060 "	283 "
11:00—11:08	1200 "	250 "
11:12—11:20	1350 "	222 "
11:24—11:32	1500 "	200 "

Short-Wave Notes

GENERAL ORDER NO. 24 of the Federal Radio Commission opens up a new telegraph band for amateurs between 28,000 and 30,000 kilocycles, or 9.99 to 10.71 meters. It also defines an amateur station as one "operated by a person interested in radio technique solely with a personal aim and without pecuniary interest." It also makes slight revisions in the telephone bands open to amateur traffic. Radio telephones are now permitted to operate in these bands:

KILOCYCLES	METERS
64,000 to 56,000	4.69 to 5.35
3,550 to 3,500	84.5 to 85.7
2,000 to 1,715	150.0 to 175.0

On March 17 a six-passenger Stinson-Detroiter monoplane left Curtiss Field on a coast-to-coast flight bearing five passengers and considerable radio equipment. A photograph of some of this apparatus, built by the R.C.A. is shown here. By the time this appears, many amateurs will have worked the plane whose radio gear was under the key of H. C. Leuteritz, and which was licensed to transmit on 120 meters using the call letters 2 XBK.

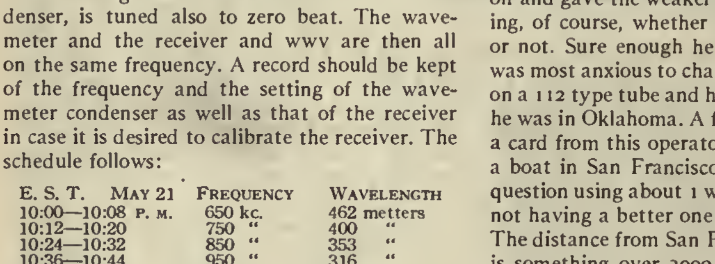
Attempts were made to get into contact with the plane from the RADIO BROADCAST magazine station, 2 GY, but by the time we got the receiver wound up to operate on the rather unusual wavelength of 120 meters, the plane was apparently too far away. We heard several commercial stations calling her, and found a lot of interesting things going on between 100 and 200 meters. For example the coast guard boats using Western Electric radio equipment could be heard all up and down the coast hammering out information about the rum fleet—probably. The stuff was in code.

Not long ago we got up at 5 A. M. E. S. T. and hammered out a CQ on our 40-meter station, 2 EJ (See our April, 1927, issue). Two stations came back at once, and on about the same frequency, one fairly loud and the other quite weak. We clicked with the louder of the two asking the weaker to QRX for a few minutes. The louder station turned out to be in Colorado and very glad to be QSO the east coast because he was using low power. After some conversation we signed off and gave the weaker station a call, not knowing, of course, whether he was still standing-by or not. Sure enough he came back, and he too was most anxious to chat. He was using 180 volts on a 112 type tube and had a call which indicated he was in Oklahoma. A few days ago we received a card from this operator stating that he was on a boat in San Francisco harbor on the night in question using about 1 watt input to his 112, and not having a better one used his Oklahoma call. The distance from San Francisco to Garden City is something over 3000 miles which is not bad for an input of 1 watt.

The following letter from M. W. Pilpel, London, England, relates the success he has had with a transmitter described in RADIO BROADCAST. Mr. Pilpel's call letters are 6 PP and his wavelength is about 45 meters. He states that he is on the air every evening up to about 7 p. m E. S. T. In this letter "NC" refers to a station in Canada, "AQ" to Iraq, "AS" to Siberia and "FM" to Morocco.

"I feel that I must write and tell about the splendid results I have obtained with a set described in your paper.

The set concerned is the "B Battery Transmitter" described in your November, 1926, issue. I built this set almost exactly as your diagram, but used 0.0003-mfd. condensers instead of 0.00025-mfd., and a grid leak variable from 1500 to 100,000 ohms instead of a fixed 10,000-ohm one.



NEW RCA AIRPLANE SET

The plate supply is from accumulators, 180 volts, and the tube used is a Marconi DE5, more or less the English equivalent to your 201-A. The antenna is a small cage with four wires and is only 15 feet long and 20 feet high. The direct ground is used.

Now for the results, with an input of 27 m/a (4.8 watts) or less I have succeeded in working four continents. Actually the best distance worked is Manoa, Pennsylvania where my friend NU-3PF gave me R2-3 during a QSO lasting nearly 1½ hours. Two first district NUs have also been worked. Then, NC (R2-3), AQ (R1!!) AS (R3), and FM (R6) outside Europe. Only three European countries possessing hams have not been worked yet, Rumania, Switzerland and Lithuania, all others have been worked on more than one occasion. LPJ at Spitzbergen gave me R3 in daylight, and OIK, when 400 miles south of Greenland, R5. The best miles-per-watt is over 900, ED 7HJ of Bornholm, Denmark, 750 miles away giving me R4 when using 0.8 watts.

I attribute these results chiefly to the steadiness of the note emitted by the set and must congratulate you on bringing this excellent little "perker" to general notice and describing it so well."

Recent Interesting Contemporary Articles

EACH MONTH we look through the welter of radio magazines and papers that come into the office. Occasionally, we read some of them. *QST*, for example, disappears from the office the moment it comes from the mail room and does not come back until whoever took it has perused every word. Then someone else grabs it. *Experimental Wireless and Wireless Engineer* (England) suffers the same experience. The rest of them from a technician's standpoint, seem mediocre, a sad fact true even of the *Proceedings of the I. R. E.* at times. The following recent articles are worth reading.

TITLE	MAGAZINE	DATE
Double Detection Detectors and Screen-Grid Amplifiers	*QST*	March
Directional Properties of Antennas	*QST*	March
The Photoelectric Cell	*Radio*	February
Frequency Stabilization on Short Waves by Quartz Crystals	*L'Onde Électrique*	January
Theory of the Antenna	*Wireless Experimenter*	March
A Radio-Frequency Oscillator	*I. R. E.*	February
Theory of Power Amplification	*I. R. E.*	February
Ideals of the Engineer by John J. Carty	*Journal, A. I. E. E.*	March
Use of Very High Voltage in Vacuum Tubes by W. D. Coolidge	*Journal, A. I. E. E.*	March

Another Useful Publication

IN SPITE of the fact that our friend C. T. Burke of the General Radio *Experimenter* catches us up, publicly, whenever we make a mistake, we still believe that every serious radio thinker should be on the list of those getting this excellent trade publication.

A similar sheet has arrived in the Laboratory. It is called the Aerovox *Research Worker* and is published by the Aerovox Wireless Corporation, 70 Washington Street, Brooklyn, New York. It, too, is worth having regularly. In our list of "Manufacturers' Booklets Available," regularly listed in the back advertising pages of this magazine this publication is listed as No. 120.

Radio School Scholarships

ANYONE WANTING a free ticket to the Radio Institute of America should get in touch with J. V. Maresca, Room 1889, Hotel Roosevelt, New York. He has charge of applications for two scholarships offered by the Veteran Wireless Operators' Association and the two offered by A. H. Grebe. Awards will be made to those American born youths over eighteen years of age who write the best letters of essays on "Why the American Merchant Marine Needs Perfect Wireless Communication."

—KEITH HENNEY.

New Apparatus

An Inside Antenna

X30
Device: Indoor Aerial. Consists of a seventy-foot spool of indoor aerial wire, a twenty-five foot length of rubber-covered ground wire, and a ground clamp. The aerial wire is made of stranded copper covered with a brown braid. *Manufactured* by the Belden Manufacturing Company. *Price:* $1.35.
Application: Designed especially for indoor antennas, the wire is flexible and can be easily wired around a room, over window frames, and because of the neutral brown color of the braid, the wire is practically invisible.

Fine New Drum Dial

X31
Device: National Type F Velvet Vernier Drum Dial. Dial light is readily removable, and has both terminals insulated from the dial. Dial numbers are engraved on strip. Drum is made of brass, with nickel plating and the dial front is silver plated. The movement has absolutely no back-lash. *Manufactured* by The National Company. *Price:* $4.50.

NATIONAL DRUM DIAL

Application: May be used in constructing any receiver. One of the best drum dials that have been received in the laboratory.

A Good Phonograph Pick-Up

X32
Device: Amplion Phonograph Pick-Up Unit. Device is complete with tone arm and volume control. *Manufactured* by the Amplion Company. *Price:* $15.00.
Application: To be used in conjunction with a phonograph turn-table and an audio amplifier to make possible the electrical reproduction of phonograph records. The tone arm is screwed down on the turn-table bed of the phonograph in such a position that the unit on the end of the tone arm can be correctly placed on a record. The Laboratory's sample of this pick-up has given very satisfactory reproduction of records and it has the advantage over some other pick-ups that it exerts but slight pressure on the record resulting in less record wear.

Resistor for the Screen-Grid Tube

X33
Device: Amperite No. 622. Filament-control resistance for screen-grid tubes. When placed in series with the tube filament and a six-volt battery, this resistance will reduce the voltage to 3.3 volts, the correct voltage for a screen-grid tube. *Manufactured* by the Radiall Co. *Price:* $1.10.
Application: May be used for filament control of the screen-grid type tubes in a receiver. Amperites for each type of tube are made. Complete data on the different styles available may be obtained by writing the manufacturer through Radio Broadcast.

Set Tester of Wide Use

X34
Device: Radio Set Tester, A. C and D. C. Model 537. This set tester is designed for the testing of all kinds of radio receivers operated from either alternating or direct current light socket power or from batteries. It will measure the various voltages used in the radio set both at the tube sockets or at any part of the set; it will test continuity of circuits, and test the tubes under the same conditions as exists when in their sockets. All tests can be made by using the voltages normally supplied to the set by its batteries or socket power with no change in connections, so that no auxiliary power supply is required. Socket adapters are supplied so that UV, UX and UY type tubes may be tested.

All of these tests are possible using the two meters contained in the instrument, which are an a. c. voltmeter having three ranges 150, 8, and 4 volts, and a d. c. volt-milliammeter which has four voltage ranges, (600, 300, 60, and 8 volts) and two current ranges, (150 and 30 milliamperes). The voltmeter has a resistance of 1000 ohms per volt and can therefore be used satisfactorily to measure the output voltages of B power units. Tests on tubes can also be made independent of any radio receiver by connecting a plug supplied with the instrument into a light socket.

AMPLION PHONOGRAPH PICK-UP

PRODUCTS of radio manufacturers whether new or old are always interesting to our readers. These pages, a feature of Radio Broadcast *explain and illustrate products which have been selected for publication because of their special interest to our readers. This information is prepared by the Technical Staff and is in a form which we believe will be most useful. We have, wherever possible, suggested special uses for the device mentioned. It is of course not possible to include all the information about each device which is available. Each description bears a serial number and if you desire additional information direct from the manufacturer concerned, please address a letter to the Service Department,* Radio Broadcast, *Garden City, New York, referring to the serial numbers of the devices which interest you and we shall see that your request is promptly handled.*—The Editor.

Manufactured by the Weston Electrical Instrument Corp. *Price:* $100.
Application: An essential instrument for the radio dealer and the professional radio service man, for it makes possible the thorough, accurate and rapid testing of a receiver.

WESTON SET TESTER

For the 250 Type Tube

X35
Device: Power Equipment for the 250 type tube. The apparatus listed below has been designed for the 250 type tube. This tube requires much more plate current than other types of power amplifier tubes and therefore the apparatus for use with it must be constructed to prevent overheating and saturation effects at high currents.

Type 565-B Full-Wave Transformer. Designed for full-wave rectification using two type 281 tubes. The plate voltage winding is 1200 volts with a center tap. There are also two 7.5-volt secondaries for the filaments of the rectifier and power amplifier tubes. *Price:* $20.00.

Type 565-A Half-Wave Transformer. This transformer is designed for half-wave rectification in conjunction with one 281 type tube. There are four secondaries: one of 600 volts for the plate voltage; two of 7.5 volts each for the filaments of a rectifier and power amplifier tubes; and one of 2.5 volts for the filaments of 226 and 227 type of tubes in case this transformer is incorporated in a complete two- or three-stage amplifier. Rated at 200 watts. *Price:* $20.00.

Type 587-A Speaker Filter. A speaker filter that thoroughly insulates the speaker from the high plate voltage and current of the last-stage tube. The choke used is of unusually heavy construction and has an inductance of approximately 15 henries and a continuous current rating of 100 milliamperes. The direct current resistance is 250 ohms. Two microfarad condensers are used on each side to completely insulate the speaker from high voltage. Connections to the input side are in the form of leads while the speaker is connected to two binding posts. *Price:* $10.00.

Type 527-A Rectifier Filter. This unit consists of a combination of two heavy-duty chokes with an inductance of approximately 13 henries each and a continuous current rating of 100 milliamperes and a condenser assembly consisting of a 4-2-4-mfd. combination rated at 1000 volts d. c. The direct current resistance of each choke is 175 ohms. *Price:* $25.00.

All the above apparatus *Manufactured* by the General Radio Company.
Application: This apparatus may be used in

constructing power amplifiers using the 250 type tube especially, although the equipment is of course suited to the construction of any power unit from which it is desired to obtain comparatively large amounts of current, say 60 milliamperes or more.

Dynamic Speaker Models

X36

Device: Jensen Dynamic Speaker: A moving-coil type loud speaker. It may be connected directly to the output of a receiver without any need of an output device, for the transformer contained within the loud speaker insulates the windings of the moving coil from the plate current of the power tube. The field winding of the speaker must be supplied with energy from an A battery (Model D-44), or from a 90-volt d. c. source (Model D-45) or from the 110-volt a. c. mains (Model D-44. a. c.). *Manufactured* by the Jensen Radio Mfg. Co.

Price: Model D-44, $65.00; Model D-45, $67.50; Model D-44-AC. $75.00.

Application: A sample of this loud speaker has been in use in the Laboratory for some time and has proved to be an excellent instrument. An elementary diagram of the loud speaker appears

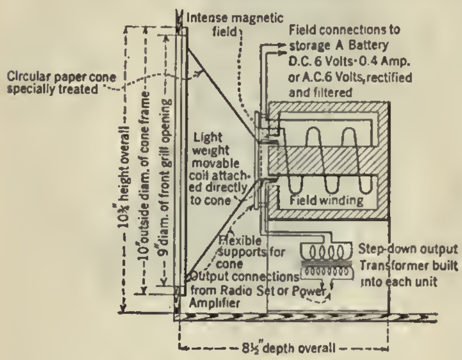
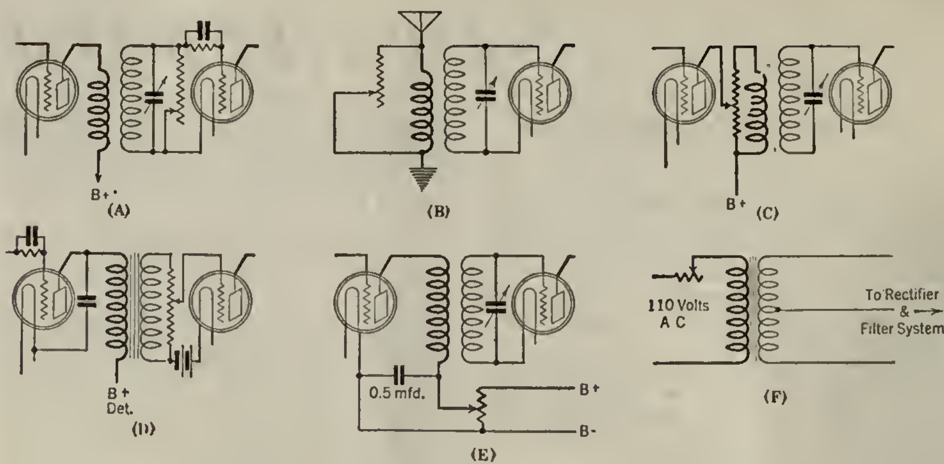


DIAGRAM OF JENSEN CONE

herewith. The cross-sectioned part represents a magnet, energized by the current flowing through the field winding. As a result there is produced across the gap in the magnet an intense magnetic field. The paper cone is arranged as indicated, projecting into the gap, and around this portion of the cone is wound a small coil of wire. This coil is connected to the secondary of the step-down transformer, the primary of which connects to the output of the radio receiver. The signal currents flowing through the coil react with the magnetic lines of force flowing across the gap and produce a torque which makes the coil move left and right. The cone, attached solidly to the moving coil, must also move with the coil and its movements produce the sounds. This loud speaker gives best results when operated in conjunction with a large baffle but will also work very well in the cabinet supplied



CIRCUITS FOR CENTRALAB VOLUME CONTROLS

by the Jensen Company. The cone unit can also be purchased without the cabinet for installation in radio or phonograph consoles.

Resistors for A. C. Sets

X37

Device: Volume Control Resistances, for a. c. receivers. The method of volume control commonly used in d. c.-operated receivers, i. e., a filament rheostat in the filament circuit of the r. f. tubes, cannot be applied to a. c. circuits because lowering the filament potential of 226 type tubes will tend to produce a hum in the loud speaker and because with 227 type tubes the emission from the heater will lag behind changes in the current through the heater filament. It is therefore necessary to use some other type of volume control. The devices listed below will be found very satisfactory.

RX-100 Radiohm, a special tapered resistance for use across the secondary of one of the r. f. transformers, preferably the detector stage. See Fig. 1-A. *Price;* $2.00.

RX-025 Radiohm, a special tapered resistance for use as a volume control across the primary of an r. f. transformer or across the primary of a tuned antenna coil. See Fig. 1-B. *Price:* $2.00.

P-112 Potentiometer. A 6000-ohm potentiometer with a special tapered resistance at the end to be used in the antenna circuit or across the primary of a tuned r. f. stage. See Fig. 1-C. *Price:* $2.00.

M-500 Modulator. A potentiometer with a special tapered resistance for the grid circuit of one of the audio stages. Used principally as an auxiliary control in a. c. circuits. See Fig. 1-D. *Price:* 2.00.

HP-050 Heavy Duty Potentiometer. A wire-wound, non-inductive potentiometer used as a plate circuit control. See Fig. 1-E. *Price:* $2.00.

PR-050 Power Rheostat. A specially constructed rheostat to carry heavy currents and an excellent control for use in the primary of a power transformer. See Fig. 1-F. *Price:* $1.25.

All of the above units are manufactured by the Central Radio Laboratories.

Application; The application of these units to a. c. circuits has been covered in the data given above. A useful pamphlet is obtainable from the manufacturers through Radio Broadcast describing these units in detail and giving further information regarding the circuits in which they are to be used.

JENSEN DYNAMIC CONE

Resistors for Power Supply Use

X38

Device: Truvolt Resistors. Wire-wound resistors, using Nichrome wire wound on an asbestos covered enamel core. Available as fixed and variable resistors as follows:

Type T, variable resistors, with maximum resistances of 200 to 50,000 ohms.

Type B, fixed resistors, rated at 25 watts, and available in sizes from 200 to 50,000 ohms.

Type C, fixed resistors, rated at 50 watts, and available in sizes from 200 to 100,000 ohms.

Type D, fixed resistors, rated at 75 watts, and available in sizes from 200 to 100,000 ohms.

Type V, center-tapped fixed resistors, available in sizes from 10 to 200 ohms, and designed especially for use as center-tapped resistors across the filaments of a. c. tubes.

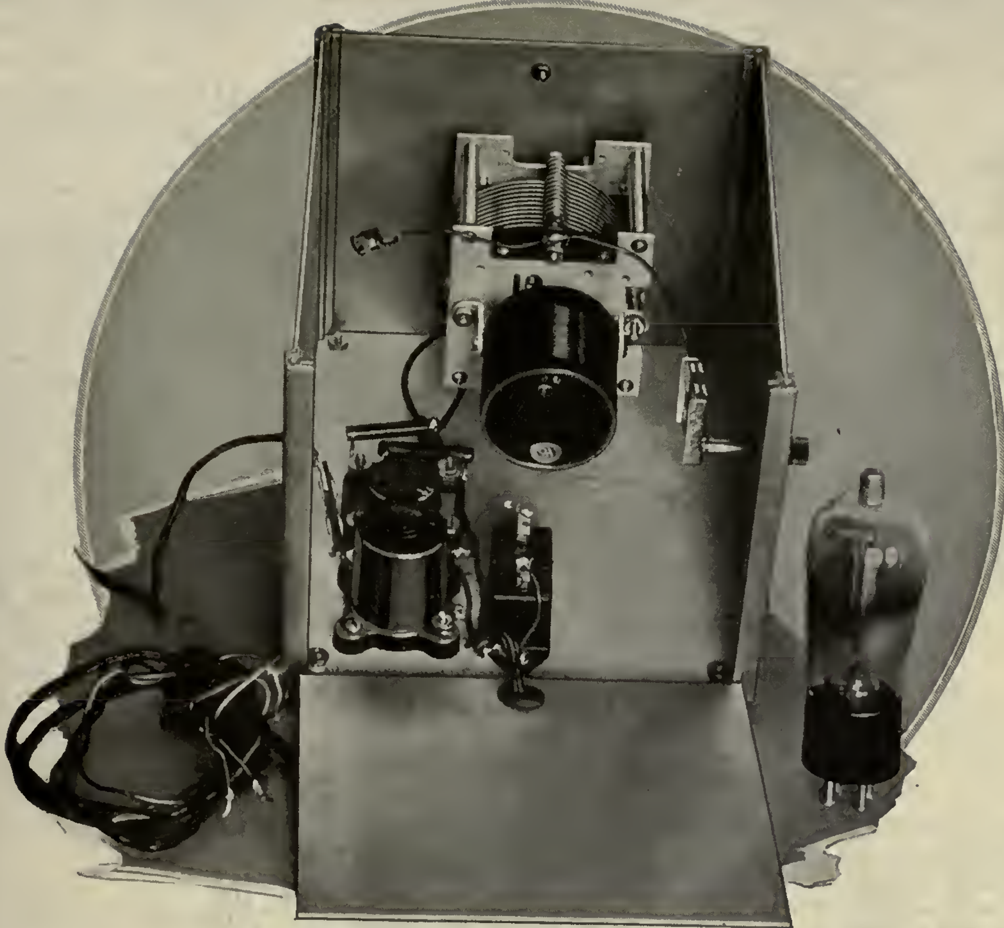
Grid Resistors, available in sizes from 10 to 2000 ohms, and designed especially for use as grid suppressors, in radio-frequency amplifiers.

Special Tapped Fixed Resistors, designed for use with the popular types of power packs such as those made by Silver-Marshall, Amertran, Samson, Thordarson, etc.

Manufactured by Electrad, Inc. *Prices:* vary according to the style and rating of resistors.

Application: The Truvolt line of resistors is very complete and units are available to meet almost every need in the construction of radio receivers and power packs. Complete data can be obtained from the manufacturer through Radio Broadcast.

TRUVOLT RESISTORS AND BELDEN ANTENNA KIT



NEW LIFE FOR A WEAK RECEIVER

The screen-grid tube can be added to any receiver, and—at the cost of one additional control—will add a respectable amount of sensitivity and some selectivity. Directions are given for using this unit with any receiver

A Screen-Grid Booster Unit for Any Receiver

By Glenn H. Browning

Browning-Drake Corporation

THE introduction of the screen-grid tube has opened a new field in r.f. amplification, for not only does this tube make possible at broadcast frequencies an amplification much greater than is possible with a 201-A type, but because of its very small capacity between control grid and plate, relative stability as an r.f. amplifier is secured.

As most experimenters know, the screen-grid tube has two grids, one forming a nearly complete shield around the plate and known as the screen grid, while the other is practically the same as the grid in the ordinary tube, and is called the control grid. The screen-grid has two effects; it shields the plate as its name indicates, and also increases the mutual conductance in such a manner that the amplification of the tube may be at some frequencies as high as 100. The function of the control grid is, as in the 201-A tube, to regulate the flow of electrons between filament and plate.

The construction of the tube may be seen in the accompanying photographs. The metal cap on top of the tube is the terminal for the control grid while the prong on the socket, marked "grid," is the terminal for the screen-grid. These connections should be carefully noted.

To get the utmost from the screen-grid tube involves careful shielding of the tube and the circuit in which it is used. There are thousands of sets which are not now shielded nor could they readily be shielded. This difficulty, in addition to the fact that it is very rare indeed that any existing circuit can be efficiently and easily altered for the successful use of the screen-grid tube makes it wiser in most cases to find ways of utilizing the high gain to be secured from the screen-grid tube elsewhere than in the receiver proper.

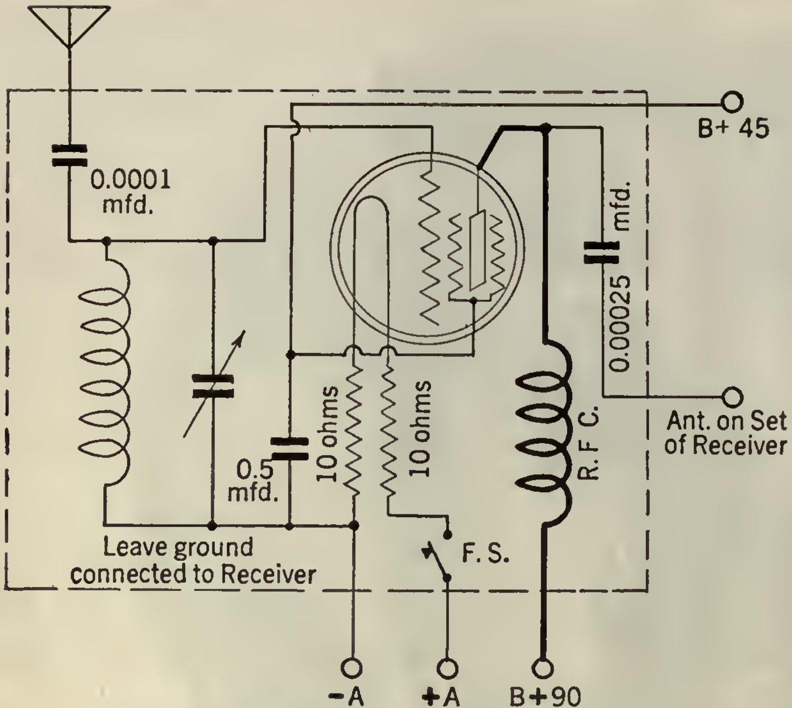
MR. BROWNING'S "booster" provides at one time a means of improving the DX *ability of any receiver and its selectivity. In the Laboratory, it was possible to hear stations that were not audible without it. It was also possible here to listen to* KDKA *with very little interference from* WABC, *only 8 miles away, while under usual conditions this is not possible at all. In our estimation, this booster should be a gold mine to service men—because nearly every one wants some little gadget like this that will make an otherwise almost-dead receiver come to life.*

We hope that Mr. Browning will design a set of plug-in coils so that this single stage of r.f. amplification may be used with short-wave receivers. It will then eliminate nearly all radiation from these receivers, as well as improve signal strength.

—THE EDITOR.

For the last year there has been an insistent demand for another stage of tuned radio-frequency amplification to be added to the Browning-Drake receivers. The writer has worked a great deal on this problem only to come to the conclusion that it was not feasible for the home-builder because of the high gain in the Browning-Drake transformers which entails careful construction, and critical adjustment of the neutralizing condensers. However, with the availability of the screen-grid tube, the problem simplifies itself considerably.

For some time the writer has been experimenting with a one-stage r.f. amplifier which could be added to the large number of Browning-Drake sets which are in use. This amplifier employs the screen-grid tube. and not only gives a tremendous r.f. amplification, but increases selectivity to a marked degree. It has also been found that the one-stage amplifier can be used



CIRCUIT OF THE BOOSTER UNIT

The antenna connection indicated will work with all Browning-Drake type receivers· with others, it is best to connect the antenna lead to the set directly to the stator plates of the first tuning condenser

adding the booster. Volume may be controlled as before on the receiving set.

HOW TO CONNECT THE BOOSTER

WHEN using this one-stage booster with other receivers, the wire on the right of the shield casing, is connected to the stator plates on the first tuning condenser. The other connections are unchanged, except that the antenna lead is connected to the proper post on the booster. The operation of the booster is very simple indeed as all that is necessary to do is to tune-in the receiver by means of the regular control and then tune the hooster.

Tuning on the booster unit is not extremely critical though it increases the selectivity of the set in a marked degree. The antenna used on the receiver when this booster is employed should be very short, in fact, not more than 25 to 40 feet, and as nearly vertical as possible. The vertical antenna will pick up relatively a stronger signal.

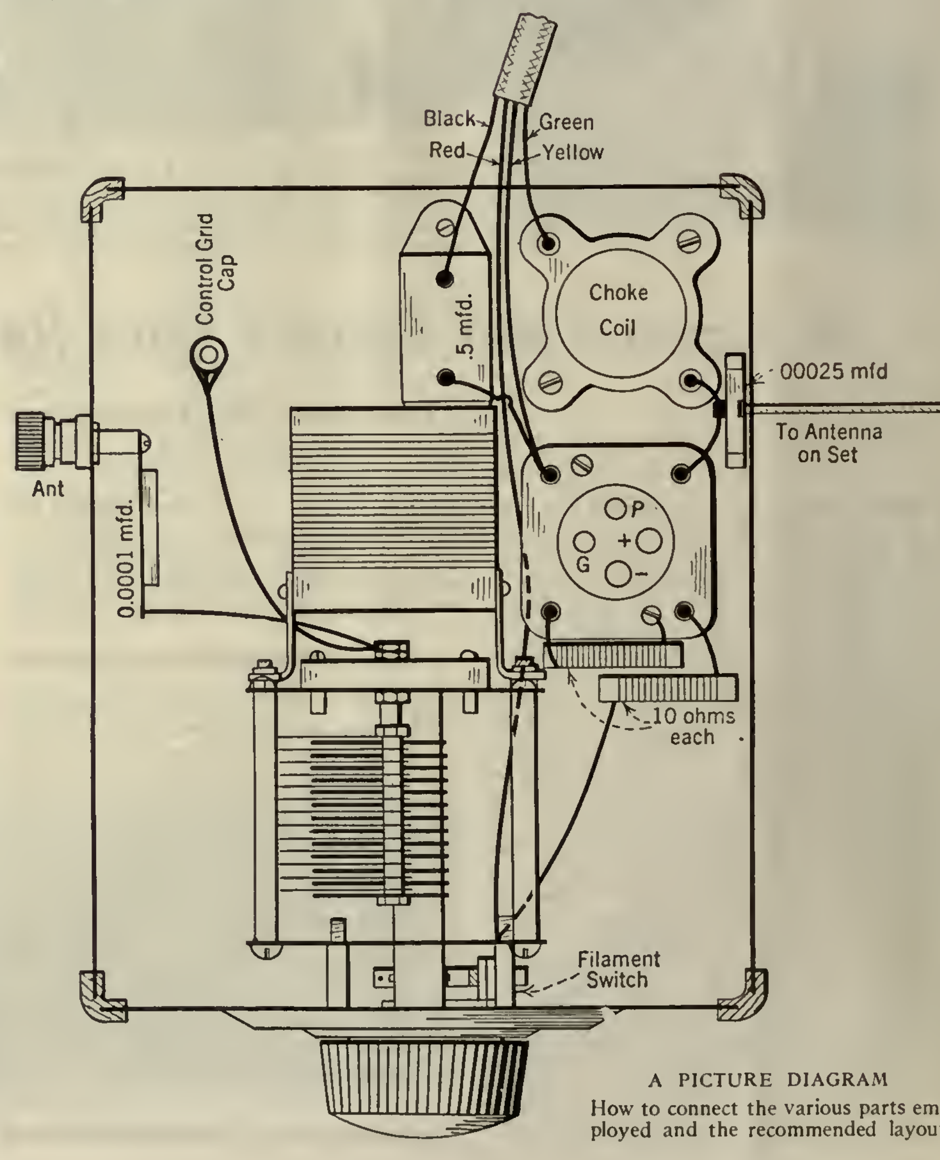
LIST OF PARTS

1 Browning-Drake Booster 322 Kit assembly. (Includes shields, the coil and tuning condenser with dial, two 10-ohm resistances, a four-wire cable, shield wire, and r.f. choke).
1 UX tube socket.
1 0.0001-mfd. mica Condenser.
1 ½-mfd. mica Condenser.
1 0.00025-mfd. Condenser.

not only on Browning-Drake sets, but on any existing receiver, simply by making a connection to the stator plates of the first tuning condenser. [The lead from the "booster" may be connected to the antenna posts of some receivers, but not all, and it is best to follow the suggestion here which is certain to work.—EDITOR.] By using this one-stage device, the writer has received signals that were inaudible before.

The assembly of the one stage screen-grid booster is quite simple. The Browning-Drake Corporation furnishes a kit consisting of the coil, condenser and dial, together with a set of aluminum shields, a radio-frequency choke, a four-wire cable, 10-ohm resistances and the mounting hardware, and all that is necessary for the constructor to purchase is a tube socket, and the three following condensers; a ½ mfd., a 0.0001 mfd. and a 0.00025 mfd.

The picture wiring diagram and the schematic wiring diagram are presented on this page. It should be noted that the stator plates of the tuning condenser go to the top of the screen-grid tube. The two 10-ohm resistances, put in as indicated, cut down the six volts from the storage battery to 3.3 volts which is the correct voltage for the screen-grid. It is noted that the one-stage booster is run from a battery as the writer does not believe it feasible to light the filament of the CX-322 from raw a.c. In using the one-stage booster on any Browning-Drake assembly, all that is necessary to do is to disconnect the antenna from the set, connect it to the antenna post of the booster, which is shown on the left, and to connect the wire lead, which is on the right of the booster to the antenna post on the Browning-Drake receiver. The ground is left in its position on the set proper. From the wiring diagrams, it may be noted that a filament switch is inserted in the plus-A battery lead to control the filament of the CX-322 tube. This makes the separate amplifier unit independent of the receiving set proper and permits it to be used on any radio set. When using the booster on Browning-Drake receivers, particular care should be taken that the set is well neutralized before



A PICTURE DIAGRAM

How to connect the various parts employed and the recommended layout

"Our Readers Suggest—"

"OUR Readers Suggest" is a clearing house for short radio articles. There are many interesting ideas germane to the science of radio transmission and reception that can be made clear in a concise exposition, and it is to these abbreviated notes that this department is dedicated. While many of these contributions are from the pens of professional writers and engineers, we particularly solicit short manuscripts from the average reader describing the various "kinks," radio short cuts, and economies that he necessarily runs across from time to time. A glance over this "Our Readers Suggest" will indicate the material that is acceptable.

Possible ways of improving commercial apparatus is of interest to all readers, The application of the baffle board to cone loud speakers, is a good example of this sort of article. Economy "kinks," such as the spark-plug lightning arrester, are most acceptable. And the Editor will always be glad to receive material designed to interest the experimental fan.

Photographs are especially desirable and will be paid for. Material accepted will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas.

—The Editor.

An Emergency Detector B Supply

IT HAS been my experience that the voltage distributing resistor system in the average B-power unit is the weak point of these devices. On several occasions the resistor passing the current to the detector tube in my receiver has gone bad. I found that an emergency connection could be effected in a few seconds, by wiring an outside resistor from the "detector B" post on the set to the "amplifier B" post on the unit. A 100,000-ohm resistor is about the correct value. The set works quite as well operating the detector tube from the 90 volts power-unit tap, through the external resistor, as it did from the original "detector B" supply post.

I rigged up the resistor mounting, shown in Fig 1, to enable me to try different values of resistors. The mounting is wired, as shown, to the "amplifier B" positive post, and the detector lead is caught under the Fahnestock clip.

Perry White, New York City.

FIG. 1

This simple arrangement can be used to supply either detector or intermediate-amplifier plate potential from a high voltage tap in the case of resistor break-down.

STAFF COMMENT

IN SOME cases it may be desirable to bypass this extra resistor. This can generally be accomplished by leaving the lead to the "detector B" post on the set (now wired to the special resistor) also connected to the original "detector B" supply post on the power unit, taking advantage of the bypass condenser included in that circuit. As the faulty resistor is probably "open" this will have no effect on the potential. If desired, the resistor may be bypassed by connecting any convenient condenser from 1.0 mfd. up, across the resistor. It is also possible to connect the external resistor directly across the "amplifier B" plus and the "detector B" plus posts on the receiver itself, without going back to the power supply unit.

The clip-wired Clarostat and the clip-wired bypass condensers suggested by Mr. Graham, elsewhere in this department, are particularly convenient in effecting temporary arrangements of this kind.

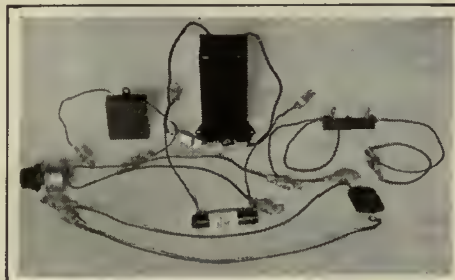


FIG. 2

The use of clip connectors permanently fastened to flexible leads for condensers and resistors greatly facilitates experimental and emergency work for many uses around the radio set

Emergency and Experimental Connections

IN MY experimental work, as well as in emergency set-ups in the perpetual endeavor to keep the family set functioning properly, I have found it very convenient to have a complete set of parts available for immediate connection by means of clips. The idea, illustrated by a few of the parts so arranged, is made clear in the accompanying photograph (Fig. 2.).

The clips used are of the small battery type, obtainable at most electrical and radio supply houses. Any type of ordinary hook-up wire may be used for the leads—I used flexible Celatsite. In the cases of certain parts, such as the condensers which already have long and flexible leads, these may be soldered directly to the clips.

The following parts which I happened to have on hand, were arranged with two-foot leads and clips:

- 1 Volume control Clarostat (variable resistor)
- 1 Universal range Clarostat (variable resistor)
- 1 Low range Clarostat (variable resistor)
- 1 Amsco 2000-ohm Duostat
- 1 400-ohm potentiometer
- 2 Fixed condensers, 0.001 mfd.
- 1 Gridleak mounting
- 2 Bypass condensers with leads, 0.1 mfd.
- 3 Filter condensers with leads, 4.0 mfd.
- 1 1000-ohm fixed resistor
- 1 2500-ohm fixed resistor
- 1 5000-ohm fixed resistor
- 1 10,000-ohm fixed resistor
- 3 60-ohm center-tapped resistors

It is also a good idea to have on hand a half dozen or so three-foot lengths of flexible wire with clips on the ends. The above parts arranged for instant clip connections, will be more than handy in all experimental work.

Herbert Graham, Chicago, Illinois

Volume Control for Resistance-Coupled Amplifiers

SOME receivers, particularly sets using a.c. tubes, employ a type of volume control such that the signal cannot be reduced without impairing selectivity to a serious extent. This consideration justifies the control of volume at a point in the circuit following the detector tube where it will have no effect on selectivity. Some circuits employ a high resistance potentiometer across the secondary of the first audio transformer in a transformer-coupled amplifier.

When using a resistance-coupled amplifier a somewhat similar arrangement can be used, and is suggested in Fig. 3. The coupling resistor in the detector plate circuit is a high range potentiometer (.1 to .25 megohms maximum) such as the Electrad Royalty, with the movable arm connected to the coupling condenser.

This arrangement provides adequate volume control without changing the frequency characteristic of the amplifier.

H. F. Kucks, New York City.

STAFF COMMENT

AS MR. KUCKS points out there are certain types of volume controls which impair the selectivity, as for example a variable resistance across the primary or secondary of an r. f. transformer. Such difficulties can be prevented by

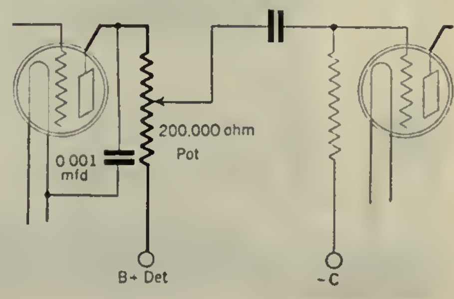


FIG. 3

A volume control circuit for use with resistance-coupled amplifiers

placing the volume control in the audio amplifier but this control has the disadvantage that it will not prevent the detector overloading on strong signals. There are several satisfactory volume controls that can be applied to a.c. receivers which will not affect the selectivity and which will also prevent detector overloading on strong signals. We mention two types.

One fairly good control is a variable resistance connected in series with the B-plus lead to the primaries of the r. f. transformers. This resistance should have a maximum value of about 200,000 ohms and a 0.1-mfd. or larger bypass condenser should be connected across it. As the amount of resistance in the circuit is increased, the effective voltage applied to the plates of the r. f. is lowered and the volume is thereby decreased. Such a control will not impair the selectivity, but, with some receivers will cause an undesirable increase in voltage applied to the other tubes in the set.

A simple type of volume control that may generally be used merely consists of a variable resistance connected between the antenna and ground posts on the set. The resistance should have a maximum value of about 50,000 ohms. Centralab, Yaxley, and others make a special resistance for this purpose.

Some Baffle Board Experiments

STAFF COMMENT

THE baffle board consists of a reflecting surface applied near a cone speaker. In many cases this takes the form of a large box, in which the cone is placed. In others it is a short horn having a relatively large bell, the cone being used as a diaphragm. In many instances, the use of baffle boards will improve reproduction of the low frequencies especially. As experimental boards are easily constructed, they are worth trying.

The two following contributions consider the possibilities of the use of baffles.

FIG. 4
A baffle arrangement with a 540 AW cone speaker

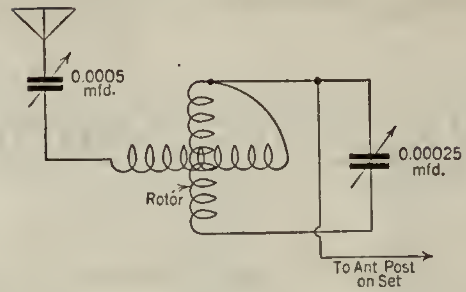


FIG. 5
An antenna tuning circuit for use with neutrodynes and other receivers having an untuned primary circuit

IN EXPERIMENTING with a Western Electric 540 AW cone I found it possible to attain a marked improvement in the reproduction of the lower audio frequencies, without apparent impairment of the higher notes through the use of a baffle board. The accompanying photograph, Fig. 4, illustrates the baffle arrangement employed by the writer.

I made a 36 by 36-inch wood frame, 12 inches deep. The front was faced with heavy roofing paper, with a circular hole, eighteen inches in diameter, cut out in the center. The cone was placed in this cabinet with the face of the cone brought as close to the opening as the frame of the loud speaker would permit. The assembly was then mounted on top of the chest of drawers as shown in the photograph, and placed in the corner of the room so that the sides of the enclosing cabinet touched the walls. By so doing the baffle effect of the sides was greatly increased, and the supporting furniture also functioned as part of the baffle.

The power tube used is a UX–171 outputting to the speaker through a 100-henry choke coil and a 9.0-mfd. condenser. This tube outputs adequate distortionless power to the baffled loud speaker with 135 volts on the plate.

A slight barrel effect in speech was counteracted by placing a piece of heavy cloth on the back of the cabinet, thus avoiding sound reflection.

Paul S. Foster, New York City.

* * *

A CAREFUL consideration of the most effective method of mounting a free-edge baffle type cone speaker is necessary if the best results are to be secured. Fairly good results can be expected by using a flat baffleboard of sufficient thickness and rigidity to be nonresonant throughout the audio range. A deep cabinet or console, however, will tend to improve the lower frequency response of the speaker by allowing a greater effective baffling area. The greater the baffling area the better will be the reproduction of the low notes.

Deep box baffles of the type to which we have reference often give rise to a resonance effect within the audio range, resulting in the exaggeration of certain frequencies, noticeable as a booming sound or barrel tone. One method of correcting this condition is to vent the baffle by cutting holes or louvres in the sides of the console. This has the disadvantage of reducing the effective baffling area and often impairs the appearance of what otherwise would be a handsome bit of furniture. At best my present suggestion is a trial and error method.

In mounting a free-edge cone in a baffling arrangement of this type, the writer finds that resonance can be completely eliminated by lining the interior with felt. Felt packing of a thickness of $\frac{1}{4}$ inch was used, although a somewhat thinner lining would probably have worked just as well. The entire interior of the cabinet, was lined with the packing and secured by glue and tacks.

D. C. Redgrave, Norfolk, Virginia.

Antenna Tuning Device

THE apparatus described below is an indispensable portion of my receiver equipment for distant reception. Many broadcast fans, located like myself at some distance from broadcast centers, will find this simple device of use to them.

On many evenings, when stations two hundred to three hundred miles away are practically inaudible, a variometer and two variable condensers, connected as shown in Fig. 5 boost the volume from ten to twenty times, often making enjoyable loud speaker reception possible. The device does not change the original dial settings of the receiver. Once the variable condensers are set to the proper capacity (to be determined experimentally) they need not be touched again, all tuning being effected on the variometer. However, the 0.00025-mfd. variable is very effective as a volume control. This apparatus is not effective on all receivers, but is designed primarily for use with sets having untuned antenna primaries, such as the average neutrodyne and tuned r.f. receiver.

A. Gaudette, Lewiston, Indiana.

STAFF COMMENT

THE arrangement described above is an antenna tuning device. The control described by Mr. Gaudette is really a combined antenna tuning device and a wave trap. In the majority of instances it can be simplified to the circuit shown in Fig. 6. Coil L may be the secondary of any available radio-frequency amplifying transformer, or sixty turns of wire wound on a three-inch diameter form. This device will be most effective on short indoor antennas.

A Spark Plug Lightning Arrester

HERE is a simple and effective lightning arrester. It consists of a good heavy spark plug, and a piece of pipe, three or four feet long, into which the plug can be screwed.

The pipe is driven into the ground and the spark plug screwed into it. The ground connection is automatically taken care of. The wire from the antenna is led to the binding post on top of the spark plug and from there to the receiver. That is all there is to it.

George Koether, Jr., Round Bay, Maryland.

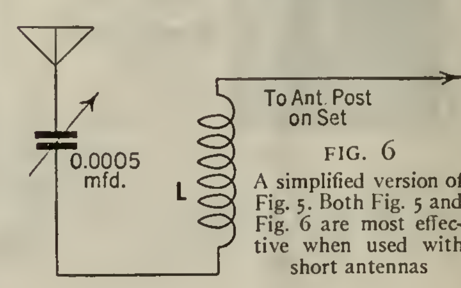


FIG. 6
A simplified version of Fig. 5. Both Fig. 5 and Fig. 6 are most effective when used with short antennas

No. 1. **June, 1928.**

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

The Amrad A. C. 7

THE Amrad A. C. 7 is another representative of the a.c. electric receiver of the neutrodyne type. This receiver utilizes seven tubes, six of which are of the a.c. type while the seventh is a 171. A study of the wiring diagram of the complete receiver installation will bring to light several novel features in design. There are four stages of radio-frequency amplification, a non-regenerative detector, and two stages of transformer-coupled audio-frequency amplification. The power is obtained from a full-wave B power unit which simultaneously supplies the B voltage for the plates of the tubes and the a.c. voltages for the filaments.

The r.f. system consists of an antenna coupling stage and three stages of Hazeltine-neutralized tuned radio-frequency amplification. The receiver is designed for a short antenna and the first r.f. stage is really a coupling stage, being untuned. The input circuit of this coupling tube consists of a radio-frequency choke, tapped for the antenna, in series with a fixed resistance, which is grounded. By utilizing this coupling tube the tuned settings of the other three stages are not disturbed by variations in antenna length or capacity. A very novel method of volume control for the entire receiver installation is incorporated in the plate circuit of this coupling tube. It consists of a variable resistance connected across the bifilar primary winding. Under normal circumstances a volume-control of this type would manifest an effect upon the grid circuit of the average tuned stage but since the grid circuit of this tube is untuned the effect of this variable resistance is that of only a volume control, without any detrimental effects upon other circuits. Each of the r.f. stages is contained in a separate can. The audio stages are not shielded and are of the conventional type, with an output transformer utilized to couple the loud speaker to the output tube.

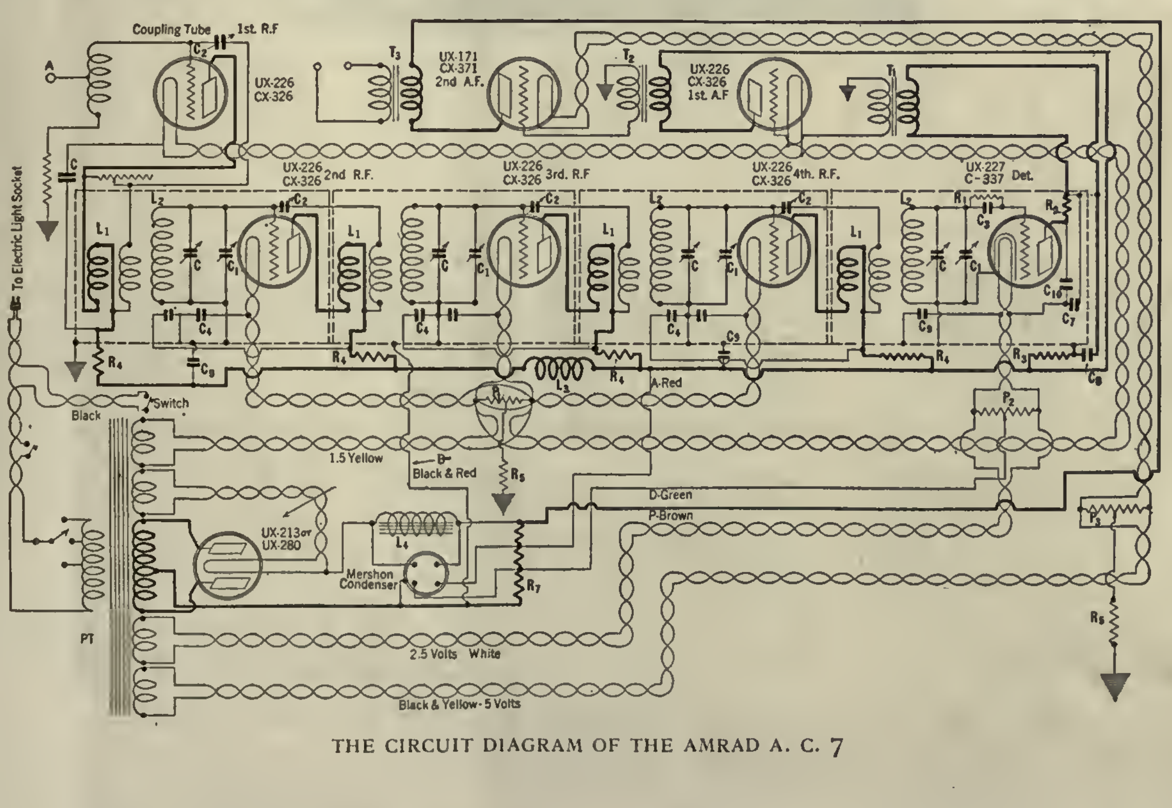
All four stages of radio-frequency amplification are neutralized, and the neutralizing condensers are designated as C_2 in the wiring diagram. The bifilar primaries utilized in this system of neutralization are marked L_1 in the drawing. The receiver is a single-control unit, the four tuning condensers being ganged together and operated from one point. A filter system, consisting of a resistance and a capacity, is incorporated into the detector plate circuit, probably to keep the a.c. hum at a low value. The plate voltages for the r.f. tubes and the detector arc obtained from one tap on the power unit, but voltage-reducing resistances located in the plate circuit of each radio-frequency

THE SET IN ITS CABINET

tube and in the plate circuit of the detector tube, reduce this voltage to the correct values for the individual tubes. It should be understood that volume control in this installation is not accomplished by plate-voltage reduction. At first glance one would assume this to be the case. Volume-control is obtained by a resistance which varies the a.c. voltage across the first-radio-frequency primary winding. Bypass condensers are used to bypass the filament and plate circuit in every stage: to further facilitate receiver stability, a radio-frequency choke is wired into the plate-voltage system in the r.f. circuit.

As was stated, the filament circuits are all a.c.; and electrical balance is obtained by means of potentiometers. These are designated as P_1, P_2, and P_3 in the wiring diagram. The grid bias for the various tubes is obtained by means of a resistance through which the plate current flows and results in a predetermined voltage drop. These voltage-drop resistances are marked R_5 and R_6. As is evident from the drawing, the grid bias voltage is of like value for the r.f. and the first audio tube, while individual grid bias is obtained for the output tube.

The power unit is of conventional type with two variations. The rectifying tube is of the 280 full-wave type. As a contrast to other filter systems employed in rectifiers, this installation utilizes but one filter choke. The required filtering action is obtained by the use of large values of capacity. A Mershon condenser of several sections (each section being of relatively high capacity) is employed. As is evident in the wiring diagram, two sections of this condenser are connected across taps of the voltage distributing resistance. This aids materially in the lowering of the effective resistance of the output circuit, and in the reduction of regeneration due to the action of this resistance as an impedance common to all circuits. The power transformer utilized consists of six windings. The primary winding is tapped for three values of line voltage. One secondary winding supplies the filament voltage for the rectifying tube, another supplies the plate voltage for this tube. The other three supply the a.c. filament voltages necessary for the various tubes in the receiver. Since a shunt potentiometer method of obtaining electrical balance is utilized, center taps on the a.c. filament windings are unnecessary. Control of the complete receiver is accomplished by means of a switch in series with the house supply circuit and the transformer primary. This switch is located on the face of the receiver panel.



THE CIRCUIT DIAGRAM OF THE AMRAD A. C. 7

No. 2. **June, 1928.**

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

The Pfansteihl A. C. 34 and 50

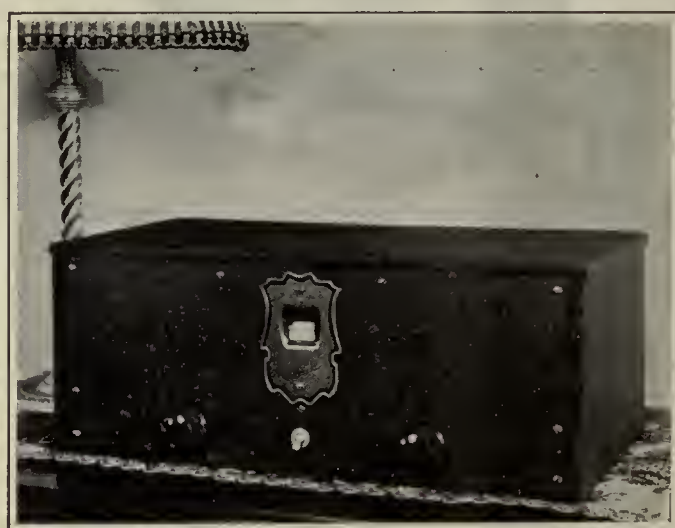
SIMPLICITY of design marks the development of the Pfanstiehl line of radio receivers. The photograph and wiring diagram shown herewith apply to both the Nos. 34 and 50 a.c. electric receivers. The 34 is the console model, whereas the 50 is the table model of the same receiver.

This receiving system employs 6 tubes, apportioned as three stages of tuned radio-frequency amplification, non-regenerative detector, and two stages of transformer-coupled audio amplification. The wiring diagram of the system is shown herewith. As is evident from the drawing, 226 type a.c. tubes are used for the three radio-frequency amplifiers and for the first stage of audio. A 227 type detector is employed and a 171 is the output audio tube, arranged in conventional transformer-coupled fashion. The four 226's are wired in parallel and obtain their filament potential from a 1.5-volt winding on the power transformer. The tuning system used in the tuned radio-frequency stages is conventional, consisting of fixed inductances and variable capacities. The method of stabilization employed makes use of grid resistances, commonly known as grid "suppressors."

In order to attain utmost simplicity, only two values of plate voltage are applied to the receiver. The three-radio-frequency stages and the two audio-frequency tubes obtain their plate voltage from the same voltage tap, while there is another tap for the detector. The first radio-frequency tube's plate voltage is governed by a potentiometer type of resistance which shunts the plate coil of the first radio-frequency tube. The standard grid-leak condenser system of detection is employed.

The audio system is conventional in every way. The volume control is a voltage divider shunting the secondary of the first audio-frequency transformer, with the center tap of this control connected to the grid of the amplifying tube.

THE RECEIVER WITH ITS POWER UNIT



THE PFANSTEIHL MODEL 50 A.C. RECEIVER

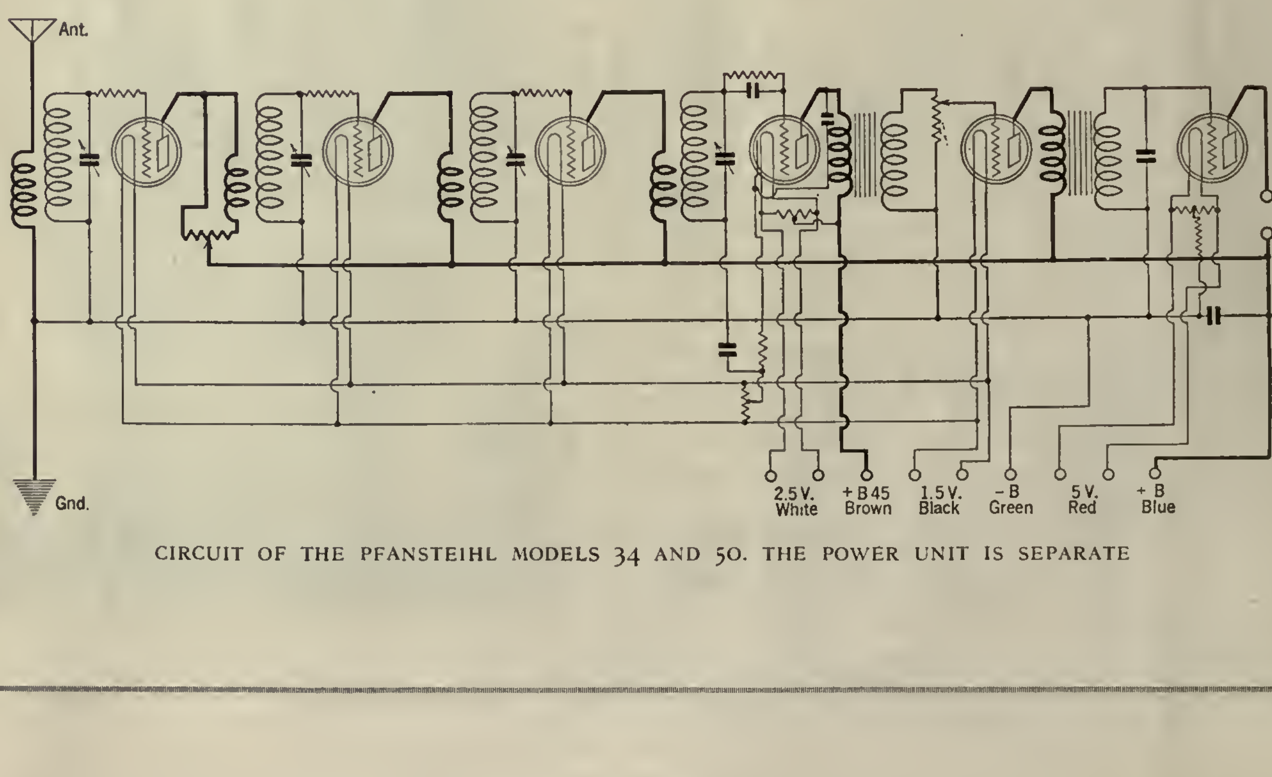
The secondary of the second audio-frequency transformer is shunted with a fixed capacity. The C bias for the output audio tube is obtained by causing a voltage drop across a resistance in the grid return lead.

The receiver is divided into two parts, the radio and audio systems being contained in one can, while the power unit is in another can. The wiring system employed in the power unit is standard. Two transformers are employed. One is the power transformer supplying the filament and plate voltages required for the full-wave filament type rectifying tube, and the other is the filament transformer supplying the 1.5 -, 2.5-, and 5-volt windings for the tube filaments. The primaries of these two transformers are connected in parallel and are designed for a 115-volt a.c. line. The filament windings supplying the 1.5 and the 2.5 voltages are equipped with voltage control resistances thus safeguarding the tube filaments in the event of an excessive line surge or increase in line voltage. The filter system consists of a two-section filter, with a single distributing resistance across the output. The "high" side of this resistance supplies the plate voltage for all tubes other than the detector tube. A tap supplies the detector plate voltage.

The electrical balance and the electrostatic balance in the filament circuit is obtained by means of mid-tapped resistances placed in parallel with the tube systems, rather than by tapping the filament voltage winding.

The loud speaker coupling to the output audio tube is direct, without any transformer or choke-condenser system. Two output binding posts are provided for the loud speaker terminals. If desired, a loud speaker coupling unit can be added to the receiver.

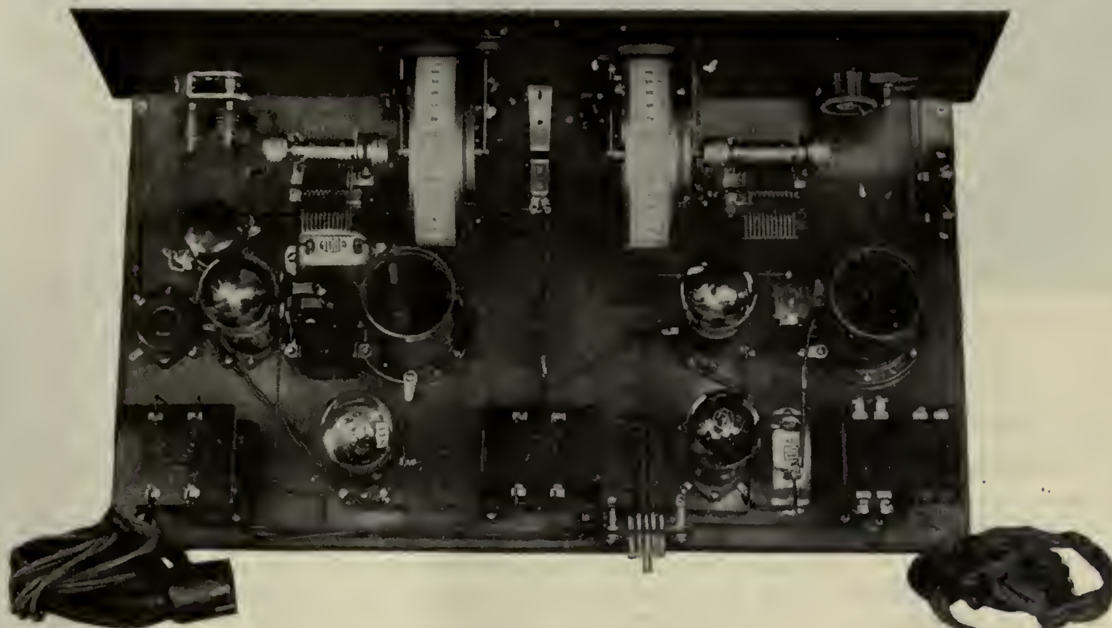
Tuning is accomplished by means of single-dial control, the second knob on the front panel being for volume control.



CIRCUIT OF THE PFANSTEIHL MODELS 34 AND 50. THE POWER UNIT IS SEPARATE

Building and Operating the A. C. "R. B. Lab" Receiver

By Hugh S. Knowles



HOW THE NEW A.C. LAB RECEIVER LOOKS—BEHIND THE PANEL

IF THE experience of those who manufacture both battery and a.c. operated receivers is any criterion there is no question about the present being an "all electric" season. This demand for a.c. receivers has been reflected in the custom set-building field where experimenters are looking askance at any circuit which cannot be modified to permit operation from the lighting circuit.

The use of a.c. tubes does not alter the fundamental operation of a circuit and for this reason it is quite natural to look for receivers using well-known and tried circuits which have been modified slightly to make the use of these tubes possible.

In this connection the receiver we are about to describe should be of particular interest to the readers of RADIO BROADCAST. It uses the familiar R. B. Lab circuit, with its possibilities for excellent performance with a minimum number of tubes together with selected parts which make possihle the realization of this performance.

The circuit itself needs no introduction, since the original and several variations have appeared in RADIO BROADCAST. Those who are interested in an exposition of the special features of this circuit are referred to the June, 1926, and April, 1928, issues. The principal advantage of this over other similar four-tube arrangements lies in its "gain" or sensitivity and in the fact that the balancing circuit of the Rice type gives accurate neutralization over the whole frequency range. The grid "suppressor" or losser method of stabilization is not used in the radio-frequency stage. This element of design improves the selectivity of this circuit and makes it more uniformly selective over the whole frequency range.

The advantages of a.c operation have been obtained together with an actual improvement in performance, due to the fact that a.c. tubes in general are somewhat better amplifiers than the standard 201-A type. Direct comparative tests between this receiver and one of the battery types indicates an improvement in gain or sensitivity, better stability and negligible hum or a.c. modulation even on the more distant stations.

One addition has been made to the circuit; a dummy socket has been connected in parallel with the detector socket. This makes it possible to plug-in a phonograph pick-up permanently. The small switch between the drum dials permits an instantaneous change from receiver to pick-up. This convenience will be appreciated by those who have had to open the cabinet, remove the detector tube, plug-in the pick-up and then perform the inverse operation to operate the receiver again.

An inspection of the schematic wiring diagram in Fig. 2 will show that two minor changes have been made in the radio-frequency circuits. The resistance R_2 has been substituted for the radio-frequency choke previously used in the mid-tap of the first coil, and the condenser C_8 has been added.

The resistance prevents very high frequency oscillations which would block the first tube. For this purpose it is just as satisfactory as the choke and less expensive. This resistance is not in any sense a "grid suppressor" at broadcast frequencies since a high-impedance choke may be used, or the circuit left open, for that matter. In practice the mid-tap connection is used to provide a means of biasing the first tube.

THE set described here is a straight four-tube "Lab" circuit receiver, arranged to operate entirely from the a.c. line. The results achieved are rather better than those from the average four-tube set, due to the high gain in the radio frequency circuit. Mr. Knowles' receiver is a well arranged set based on exactly the same circuit, with the exception of provision for a.c. operation for the filaments, that was described on page 423 in this magazine for April, 1928. That unusually interesting story dealt with the engineering design which went into this receiver and exact measurements of its performance.

—THE EDITOR.

THE CIRCUIT

THE principal circuit modifications are those made necessary by the a.c. tubes. Three 227 type tubes are used and a 171-A type in the last audio-frequency stage. Heater type tubes have been used in the radio-frequency, detector, and first audio-frequency stages because of their comparative freedom from hum or ripple. Tubes of the raw a.c. type may be adjusted to give very little hum but any change in the effective plate voltage increases the a.c. modulation considerably.

The filament current for the tubes is supplied by a step-down transformer T_3. To insure long heater life, care should be taken to see that this transformer is one of the new types designed to give 2.25 volts. The old type supplies 2.5 volts.

Bias for the radio-frequency and first audio-frequency circuits is secured by taking the drop across a resistor in the plate circuit of the tubes. This method is quite satisfactory where a single stage of radio-frequency amplification is used.

No B socket-power device has been used in the receiver since it was felt that many constructors would have ones which were previously used with battery-type receivers and others would have power amplifiers in which such a B-power supply was included. Where this is not the case any good quality power unit may be used and the receiver made "all electric."

In most cases it is advisable to use a C battery for the power tube. There is really little or no objection to this practice since the life of the C battery is determined by its "shelf life" which may be in excess of a year. Details for avoiding the use of this battery will be given later. (See Fig. 1).

THE LAB SET IN ITS CABINET

Special coils are available for this circuit and receiver which require no alterations. Any of the coils designed for a 0.0005-mfd. condenser may be used however. The Aero U95 set has two coils and will be discussed as a convenient and typical set which may be modified.

REVAMPING STANDARD COILS

REMOVE the hinged primary winding from the antenna coil leaving nothing but the main secondary winding connected to terminals 1 and 6. Remove the primary from the detector coil by carefully breaking the bakelite tubing on the inside and unsoldering the leads going to terminals 2, 3, 4 and 5.

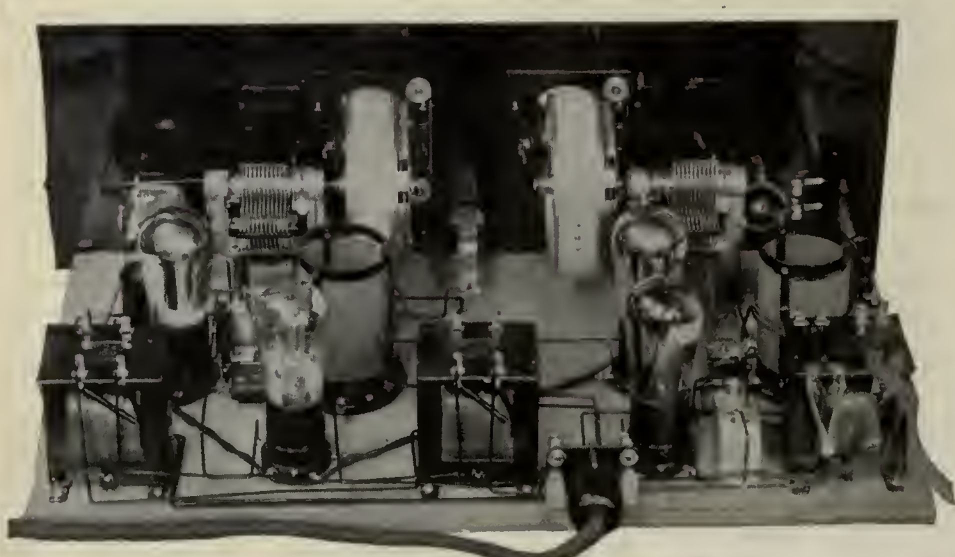
Tap one of the coils at the center turn vertically above terminal No. 1. Tap the other coil one third of the way up from the bottom vertically over terminal No. 2. Wind a thin strip of insulating material such as thin celluloid or varnished cambric about half an inch wide over the center of the mid-tapped coil. Pierce a small hole in the insulation and bring out the center-tapped strip through it. Wind eight turns of wire (No. 28 d.c.c. is all right, but the size is electrically not at all important) on each side of the midtap for the primary. Anchor the two end turns by looping them under the vertical bakelite coil support.

The baseboard and panel should be prepared in the usual manner. The template drawing, packed with the drum dials may be used as a drilling template.

Because of the height of the drum dials, the condensers, C_1 and C_2, must be mounted on "stilts" or bushings. In this case two pieces of brass tubing cut to the proper length were used. As the condensers are mounted in this receiver, the reading of the drums increases with wavelength. If the readings are to increase with frequency the condensers should be reversed. The full floating shafts make this possible. This feature also permits bakelite or hardwood shafts to be substituted. These will be discussed under the operating details.

The location of the parts is very important. In experimenting with the layout, for example, it was found that moving the choke, (L_4), over between the drum dials made the set unstable. This trouble was found to be due to the greater length of the "hot" plate lead and not to coupling between the choke and coil as might have been supposed. A discussion of the important leads to watch appeared in the June, 1926, RADIO BROADCAST under the title "Additional Notes on the R. B. Lab Circuit."

There is nothing "tricky" about the wiring. All a.c. filament leads should be twisted. Bus bar wiring was used in this set so the connections could be easily traced in the photographs. All the battery leads may be cabled if flexible wire is used. There is no objection to using "bee" line or direct point to point wiring if the leads are carefully spaced. For details on the arrangement of the leads see the photographs and Fig. 3.



AN UNUSUALLY EFFICIENT SET IN SMALL SPACE

The two A-battery leads on the cable are not used. If an outside C battery is to be used for the radio-frequency and first audio-frequency stages it may be added by making the following changes: Remove R_3 and C_7 and connect the leads going to the K terminals on the 227 sockets to the minus B or yellow cable terminal. Connect the lead going to the minus C terminal of the first audio-frequency transformer and the one connected to R_2 to the black cable terminal. Connect C_7 across the black and yellow cable terminals. The C battery is then connected externally by using the yellow and black leads as the positive and negative leads respectively.

WHEN A B-POWER UNIT IS USED

IF B-power unit which supplies 180 volts is used, a C battery with proper potential for the tube employed should be used for the power tube. Where the power device supplies 200 volts or more, an arrangement such as indicated in Fig. 1 may be used. A 30-henry choke and 2.0- or 4.0-mfd. condenser should be used to keep the direct current out of the speaker. When the speaker return is connected as shown, the 2000-ohm grid biasing resistor is not in the return circuit and this insures better reproduction of the lower audio frequencies.

No output device is used in the receiver. This reduces the cost of the parts when a 112-A type tube is used or a 171-A type with only 135 volts on the plate. If an external power amplifier is to

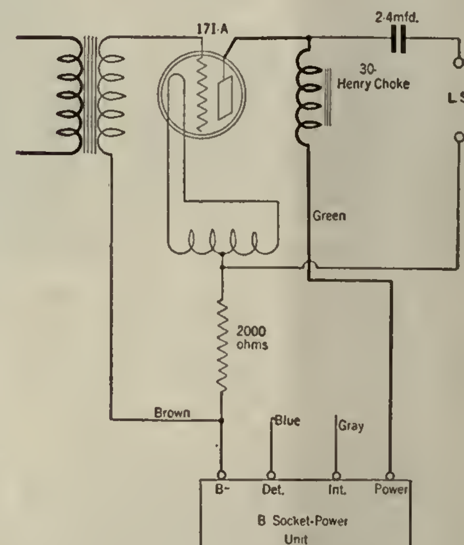


FIG. 1

be used the last audio-frequency transformer may be omitted. In some cases the power amplifier includes an audio stage ahead of the power tube and in this case the detector output may be connected directly to the speaker jacks on the cable terminal.

The dial lights should be connected in parallel across the filament of the 171-A tube.

Very little adjustment should be necessary after the receiver is completed. In adjusting the balancing circuit the "dead filament" method is not very desirable nor convenient in this case. Tune-in a carrier in the short-wave section of the broadcast band and set the detector regeneration control so the set just oscillates. Use a screw driver made from a bakelite or fiber strip to adjust the balancing condenser. Tune the radio-frequency stage first to one side of the carrier and then to the other slowly while adjusting the "equalizer."

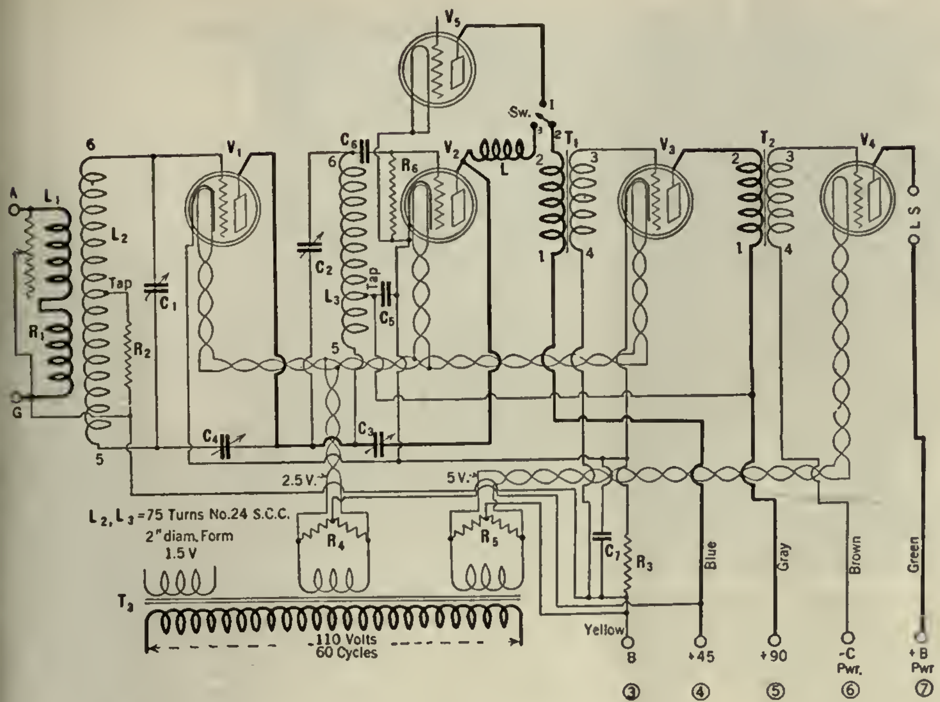


FIG. 2

constructor prefers to make his own coils, are indicated on the diagram, Fig. 2.

PARTS LIST

L_2, L_3 Aero Products Co., (1) Pr. U-95, or Special Lab. Coils	$ 8.00
C_1, C_2 Hammarlund, (2) ML-23 Condensers	11.00
C_3 Hammarlund, (1)-MC-15 Midget	2.00
L_4 Hammarlund (1) RFC-85 Choke	2.00
C_4 Hammarlund, (1) Equalizer	.50
Micarta (Westinghouse Co.), (1) 7" x 21" x ⅛" Black Panel	2.20
R_1 Electrad (1) Type P Volume Control	1.50
R_2, R_3 Electrad (2) 500-Ohm Grid Type Resistors	.50
R_5 Electrad, (1) V-30 Resistance	.75
R_4 Electrad, (1) V-10 Resistance	.75
Yaxley, (1) 669 Cable	3.25
Yaxley, (1) S.P.D.T. Switch No. 30	.90
T_1, T_2 Silver-Marshall, (2) 240 Audio Transformers	12.00
T_3 Silver-Marshall, (1) 247 Filament Transformer	5.00
Eby, (3) 5-Prong Sockets	1.50
Eby, (2) 4-Prong Sockets	.80
Eby, (2) Binding Posts	.30
C_7, C_8 Tobe, (2) 1.0-mfd. Bypass condensers	1.80
C_6 Aerovox, (1) 0.00025 Grid Condenser	.40
R_6 International Resistance Co. (1) 2.0 Meg. Grid Leak	.50
International Resistance Co., (1) Leak Mount	.50
National Co., (2) Single Drum Dials	9.00
	$65.15

When the adjustment is properly made there will be a slight "swishing" sound as the r.f. circuit is tuned to the station and the signal will clear up. If the detector is placed on the point of oscillation, there will be no tendency for the r.f. stage to make it oscillate as the r.f. dial is turned. It may be necessary to readjust the regeneration control, (C_3), slightly to make the balance adjustment more exact although the setting is not very critical.

After the set is balanced, the effect of hand-capacity should be tried on a weak station. If there is any appreciable effect, a bakelite or hardwood shaft should be substituted for the brass one used with each condenser. The effect may be further reduced after this change has been made by grounding the metal frame of the dials.

If the antenna stage tunes broadly it is an indication that the antenna is too large and the effective capacity should be reduced by connecting a fixed condenser about 0.0001-mfd. capacity in series with the antenna lead. The selectivity of the first stage should be measured with the volume control in the full "on" position since this resistance reduces the selectivity. When the set is tuned to a station where the volume control is near the "off" position, the question of selectivity is never important.

Since the volume control is in the radio-frequency circuit, special provision must be made for controlling the volume of the phonograph pick-up arrangement. Nearly all of the standard pick-ups with which we are familiar are sold with a special volume control.

To minimize hum, the B-power circuit should be grounded. Usually the ground works most satisfactorily on the minus B lead. In some cases the hum is reduced by grounding the plus 45-volt tap which in this set connects to the heater winding mid-tap. Only one of these leads should be grounded, however.

If an outdoor antenna is not available, the experimenter may try connecting a 0.002-mfd. fixed high quality mica condenser from one side of the house-lighting circuit to the antenna binding post. Both sides of the line should be tried since one side may be grounded. In this case the line acts as the collector and the signal is brought to the receiver much as it is in carrier-current telephony.

The list of parts below are those used in the model described here. Other parts, electrically and mechanically similar, may of course, be used.

The coils L_2 and L_3 are special and are supplied by Aero Products. If the builder desires to revamp the standard Aero coil set, No. U95, he should follow instructions on page 94. The dimensions for all the coils, in the event the

ADDITIONAL PARTS

(Needed to complete the set as described).

(1) Phonograph pick-up, with volume control.
(1) B Power-Unit, furnishing a maximum voltage of 220, at 40 mils., with taps as follows: 45, 90, 180, -40.
(3) a. c. 227 type tubes.
(1) Power tube, Type 112-A or 171-A (See Text).
(1) C Battery (Optional, see text; rating depends on power tube used).
(1) Corbett cabinet to accommodate panel (7 x 21 x ⅛").

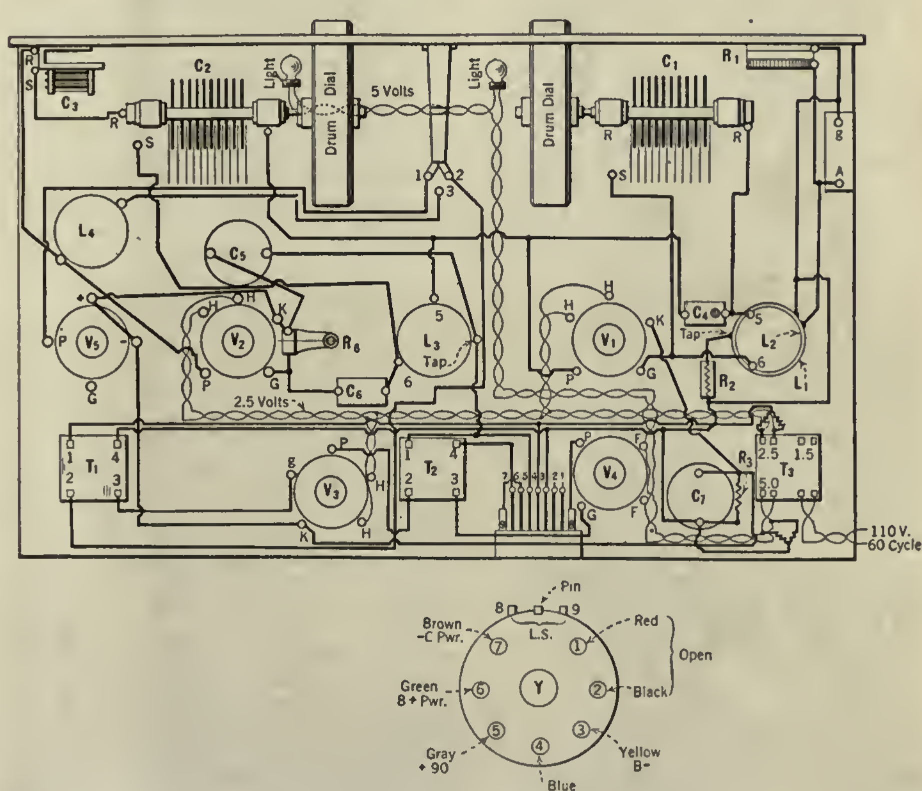


FIG. 3

Using the Screen-Grid Tube in Popular Circuits

By THE LABORATORY STAFF

MANY experimenters have written the laboratory for information to enable them to use a screen-grid tube in the r.f. stage of such circuits as the R. B. Lab., Universal, Aristocrat, Browning-Drake, and other sets consisting essentially of a stage of radio-frequency amplification followed by a regeneratve detector. The adaptation of this tube to the latter receiver has been described in the May RADIO BROADCAST and, in the same issue was described an a.c.-operated all-wave receiver using a screen-grid r.f. stage with the tube operated with a.c. on its filament.

There were no special problems involved in the design of an a.c. Lab set using a type 227 tube in the r.f. stage and the construction of such a receiver was completed with little trouble; the result of this work has been described in the preliminary article in the April issue and in the construction article appearing in this issue. After the construction of the a.c. set had been completed, experiments were made to determine how satisfactorily the type 222 could be substituted for the 227 in the r.f. stage.

The tests described here have been confined to the "Lab" receiver, and since individual tests on the various receivers mentioned in the first paragraph have not been made it cannot be stated positively that the tube will work equally well in all these circuits. However, since they are all essentially the same, the operation of the screen-grid tube as an r.f. amplifier, in these various sets, shouldn't differ very much.

The experiments on the "Lab" circuit were begun by first setting up the receiver for operation with a 227 in the r.f. stage. A modulated oscillator (the construction of which was described in the June, 1927, issue) was located about 10 feet away and its output cut down until the signal from it was just audible in the output of the "Lab" set. The 227 was then removed and the circuit rewired for the screen-grid tube in place of the type 227 tube in the r.f. stage with the filament of the screen-grid tube operated from a storage battery. The circuit is given in Fig. 1. The plate of the screen grid is coupled, through a fixed condenser, C, with a value of 0.0001 mfd. or larger, to the grid end of the coil in the detector grid circuit. The plate voltage for the CX-322 is obtained through the r.f. choke. Using the 322 there was quite a definite increase in the output of the "Lab" receiver. The change in detector plate current—which is a measure of the signal impressed on the grid of the detector—was too small to measure when the 227 was used. With the screen-grid tube, the change in plate current was quite noticeable indicating a definite increase in gain due to the screen-grid tube. This circuit has the disadvantage that the 322 must be supplied with filament current from a battery source. The filament of a 322, being the same as that in a 120 type tube, requires 0.132 amperes at 3.3 volts which may be supplied economically from three dry-cells but it would, of course, be an advantage if the filament could be operated by a.c. supplied by the filament transformer used to heat the filaments of the tubes in the circuit.

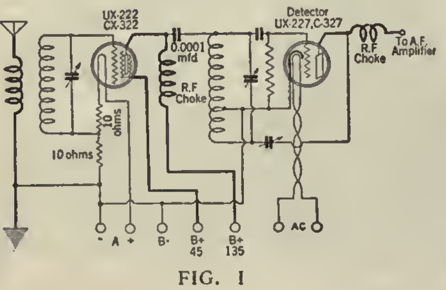


FIG. 1

The next step, therefore, was to rewire the "Lab" circuit for a.c. operation of the CX-322 using the same circuit as was used in the all-wave receiver. The plate voltage was 135 volts and the screen voltage 45 volts, both obtained from B batteries. Filament voltage is obtained by connecting the 1.5- and 2.5-volt windings on the filament transformer in series as indicated in the circuit, Fig. 2, so that the voltages add. The voltage is then reduced to 3.3 by means of a 5-ohm resistance connected in series with one side of the filament circuit. If the two windings are connected so that the voltages buck each other the filament of the screen-grid tube will not light and the connections to one of the windings should then be reversed. A 1500-ohm resistor, by-passed with a 0.01-mfd. (or larger) fixed condenser, is connected between the center-tapped resistance and minus B to supply C voltage for the grid of the 322 type tube. The complete circuit is given in Fig. 2.

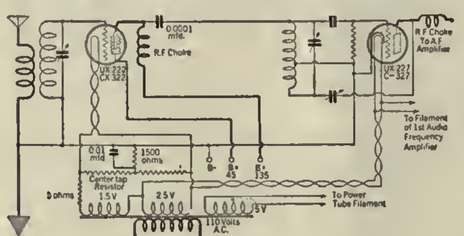


FIG. 2

This complete a.c. circuit for some reason, not yet determined, seems much more tricky than the d.c. circuit of Fig. 1, and in general, the performance of the circuit with a.c. on the 322 filament was not altogether satisfactory. The operation of this complete a.c. model had the disadvantage that the output of the receiver contained a loud hum when the detector was put into oscillation and the two tuning circuits brought into resonance. Apparently under such conditions the 322 began to oscillate. A definite increase occurred in the current flowing in the screen grid circuit. This trouble was not caused by common coupling in the battery supplying the screen circuit for the same effect was noticed with a separate battery supply to the screen grid.

When the detector circuit was not oscillating the output of the receiver was quiet. Therefore, the only practical disadvantage of the arrangement was that it made it difficult to tune-in signals, especially weak ones, by means of a squeal for the hum is loud enough to make a faint heterodyne whistle inaudible.

Some experiments were now made using a neutralized circuit. In this model of the "Lab" receiver, the lead from the plate of the r.f. amplifier to the detector coil is several inches long and, although when using a 227 in a Rice-neutralized amplifier the long lead will have no effect on the stability of the circuit, it was thought that it might be causing some trouble when using a 322 without neutralization. We therefore changed the circuit of the r.f. stage to that given in Fig. 3. The small twisted lead connected to the grid and plate of the 322, consisted of two 2-inch lengths of insulated wire twisted together. These wires constituted a small condenser and were used to increase the grid-plate capacity of the tube to about 0.00001 mfd. (10 mmfd.) so that the circuit might be neutralized with a standard neutralizing condenser. The neutralized receiver gave somewhat more stable operation than the unneutralized circuit but the hum, with the detector oscillating, was still present.

As a result of these experiments we are unable, for the present, to recommend the use of a 322 in the "Lab" circuit *with its filament operated on a.c.* Those of our readers who have a d.c. operated "Lab" receiver may use a 322 in accordance with the circuit given in Fig. 1 and the receiver will give somewhat greater gain than was obtained using a 201-type tube.

In some cases it may be found that the selectivity of the circuit using a screen-grid tube is not as good as when using a 201-A type tube as the r.f. amplifier. The selectivity may be improved, however, by substituting a midget variable condenser with a maximum capacity of 0.0001 mfd. for the fixed 0.0001-mfd. condenser connected between the plate of the screen-grid tube and the grid end of the detector coil. The selectivity of the circuit may be adjusted to a satisfactory value by varying the setting of this small condenser.

The results of these experiments will be applicable to other receivers of the same type as the "Lab" set. To revise these other receivers for screen-grid operation, it is simply necessary to remove the connection to the NP winding, i.e., the primary and neutralizing windings of the r.f. transformer and then connect a lead from the plate of the 322 through a condenser with a capacity of about 0.0001 mfd. or larger to the grid end of the secondary coil in the detector's grid circuit. Voltage for the plate of the screen grid tube should be supplied through an r.f. choke, Fig. 1, which should have an inductance of 85 millihenries or more.

Experiments, as have been described here, can readily be duplicated in a home laboratory. To many of our readers, experimenting with sets and circuits in their own small lab., equipped in many cases with instruments made from descriptions that have been given in RADIO BROADCAST, is proving an intensely interesting part of their radio training. How much one really knows quantitatively about radio engineering, depends almost directly upon how many and how systematically experiments have been made; experiments not carried out with a definite aim in view, generally yield no concrete results and do not greatly increase one's knowledge of radio phenomena. The Laboratory will always be glad to hear from any readers who do, or have done, any such experimenting.

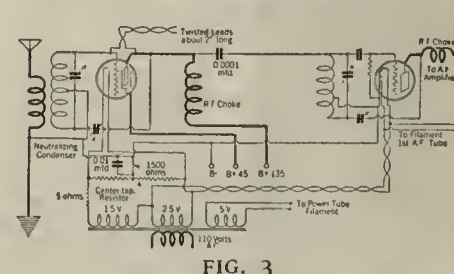
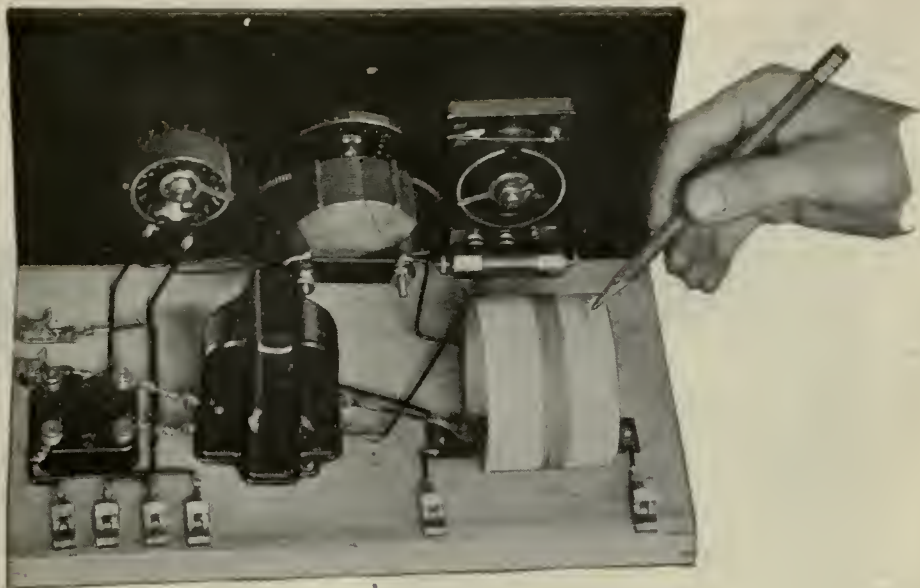


FIG. 3



AN EASY SET TO BUILD

Little explaining need be done if this illustration is compared with Figs. 1 and 2. The "loop tap" indicated by the pencil is not used in this set but is shown merely to indicate how this type of tap is made. In this coil, the tap employed is near the detector and cannot be seen in this photograph.

A Good Crystal Receiver for the Beginner

By KEITH HENNEY

Director of the Laboratory

THE receiver illustrated above is simple to built, costs but little, delivers high-quality signals, and is reasonably selective. It provides an excellent receiver for the beginner to try his hand at—after having put together this array of apparatus he has the whole world of radio home construction at his feet. There are many people who would like to listen to local broadcasting without a great expenditure of cash, either for the radio set or for its upkeep. This set will provide good signals from broadcasting stations not too far away at small cost.

The receiver consists of a tuner, a crystal detector, an amplifier and a pair of head phones. Anyone with a soldering iron and a pair of pliers can assemble it in an hour. The disadvantages of the receiver are few: it is not selective enough to distinguish between stations operating within 30 kc. of each other; it will not receive the "coast"; but for reception from locals or powerful stations up to 100 miles away it is excellent.

Because of the special electrical characteristics of the crystal—in this case, a piece of carborundum—it is possible to use a high-ratio audio-frequency amplifying transformer. The step-up as between primary and secondary circuits in this case is 6:1. Any present-day transformer of such high ratio, used with a vacuum tube detector circuit would give comparatively poor quality —the low notes especially would suffer.

The coil can be made at home, or any commercial coil may be employed provided it has the proper number of turns to cover the broadcasting band with the condenser used and provided it is not too difficult to solder a few taps on it. The condenser may be any assembly that happens to be in the builder's junk box. Naturally, the better the coil and the condenser the better the final result.

A good way to wind the coil is to place a rat tail file, a pencil or a piece of dowel rod through the spool containing the wire which is to be wound on the coil form and to place the spool on the floor. Two holes are drilled in the ends of the coil form and one end of the wire from the spoil is looped through one of these holes. A weight, one's feet for example, is placed on the rat tail file, and the wire wound on the form. The purpose of the weight is to keep the wire taut so that it goes on the form tight enough that it will not fall apart under temperature or humidity changes. When the proper number of turns has been wound, the wire is cut and the end looped through the second hole in the coil form. The diagram, Fig. 1, indicates the exact number of turns recommended for this receiver. Taps should be made at three places, dividing the coil into four equal parts. These can be made by twisting a loop of wire when it is wound on the form or by soldering short lengths of wire to places where the insulation has been scraped from the wire after winding. The loop method is shown in the photograph above.

Strongest signals will be obtained with the antenna wire attached to one end of the coil and the ground to the other. At the same time the selectivity will be poorest. To improve the selectivity, the antenna may be tapped on to the coil as shown in the accompanying illustiation, or an additional winding of about 10–20 turns may be wound about the larger coil and the antenna and ground attached to it. The antenna should be about 75 feet long.

Still greater selectivity may be obtained by tapping the detector circuit to only a part of the coil. Note that this was done in this receiver. See Fig. 1. This is because the crystal is a low impedance detector and increases the effective resistance of the tuned circuit consisting of the coil and condenser. When tapped across part of the coil this increase in resistance, and resulting decrease in selectivity, is not so marked. The arrangement used in the Laboratory is shown in Fig. 2. In the Laboratory, signals freer from outside noise or "interference" were secured by not grounding the crystal circuit. This may not be the case generally and for this reason the constructor should try grounding the circuit as shown in the dotted lines.

With this receiver, tested in our Laboratory, and using the tapped arrangement, it is possible to hear WJZ 30 miles away when WEAF is operating 8 miles away although with bad interference. With a wave-trap tuned to WEAF, considerable improvement in WJZ's signals is noted. WJZ cannot be heard at all if the detector is connected across the entire coil.

The parts actually used in the set photographed follow, and any similar apparatus may be used. It is even possible to hear signals with a crystal, home assembled, such as galena or silicon—a very cheap detector. The home constructor is advised against such procedure. The Carborundum unit is recommended because it is a compact, stable, and sensitive unit, and because it is possible to use a biasing voltage on it to increase its sensitivity.

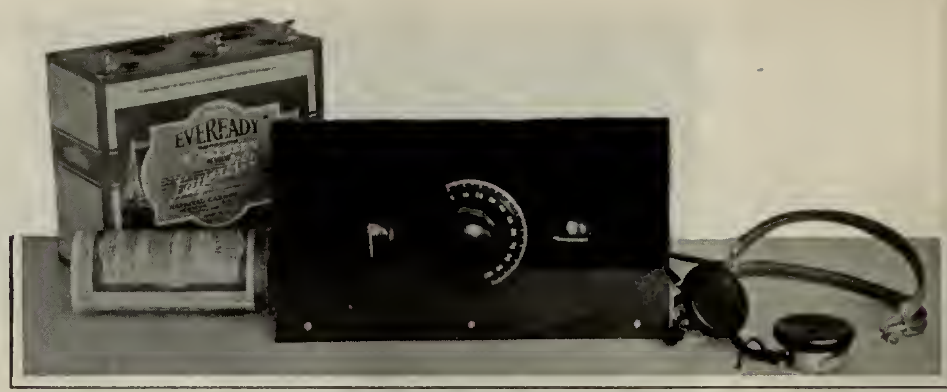
The constructor may use a small flash-light cell as the biasing battery or he may use the voltage obtained from dry cells used to light the filament of the amplifier tube. Using the extra cell is simpler, but has the disadvantage that it is an additional unit which needs replacement. If the dry cells are used, the dotted lines in the diagrams should be followed, or as in the insert in Fig. 2, where the voltage drop across the rheostat is used.

It does not matter where the various parts are located on the base board. One arrangement is shown in the photograph. The picture wiring diagram, Fig. 1, shows where the wires go.

The signals from this receiver may be amplified by any of the power amplifier units now readily obtainable. If a two-stage amplifier is used, such as is made by Samson, Amertran, Silver-Marshall or others, the output of the detector may be used and the amplifier tube, transformer, and accessory apparatus shown in this model may be eliminated. (Dotted lines in Fig. 2)

The rheostat is used to turn on and off and to control the current through the amplifier filament. It should never be turned on further than is necessary to bring in the signals at proper volume. An experiment will show that turning it beyond this point does not increase signal strength. As a matter of fact such a procedure only decreases the life of the batteries and the tube. One 45-volt B-battery block and three dry cells will last several months with such a simple receiver.

After constructing such a receiver there is the possibility of adding another stage of audio amplification for loud speaker signals, and the Laboratory will be pleased to supply information on how to do this to those who write. There is also the possibility of adding a stage of radio-frequency amplification to such a receiver, thereby making it much more selective and sensitive and as a result to increase its distance-getting ability. In fact, a three-tube set using the Carborundum unit as a detector provides the listener with a high quality, reasonably selective receiver for reception from stations within several hundred miles. The Laboratory has received a number of letters from readers who have done very creditable DX work on such an outfit.



SIMPLICITY ITSELF

The panel is 7″ × 12″ and can be fitted into any cabinet which suits the owner. The Remler dial noted in the parts list was not available when this photograph was taken

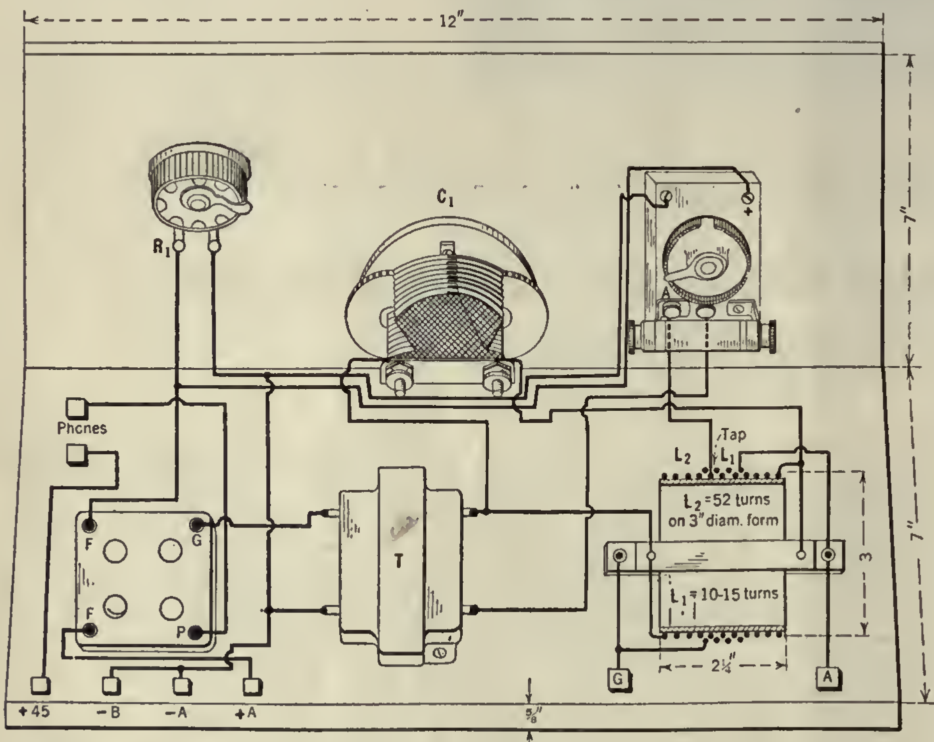


FIG. 1

How to place and connect the parts employed

How such a receiver as is described here is used in RADIO BROADCAST Laboratory may be of interest. At times considerable noise is picked up in the Laboratory from the presses, which print RADIO BROADCAST and many other magazines, making the testing of receiving equipment impossible. Down at the shack, a distance of about 1000 feet from the Laboratory where 2 GY is located the "air" is quiet. The receiver illustrated here is installed there and permanently tuned to WEAF. The output from the detector is sufficiently high that it can be placed on a wire line coming to the Laboratory where it is fed into a two-stage amplifier and thence to a loud speaker. When necessary, the first-stage amplifier on the base board with the detector is thrown into the circuit by means of an extra line and the output from it is put on a third pair of wires. This output may be used in connection with a single power stage or loud speaker operation. At all times, when near-by broadcasting stations are on the air we have good signals available in the Laboratory for testing purposes.

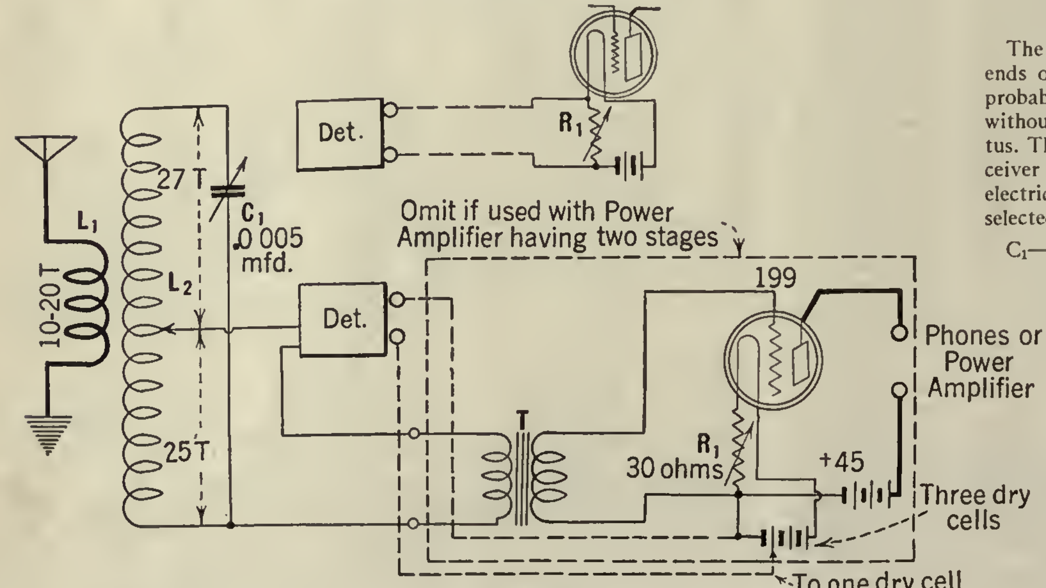


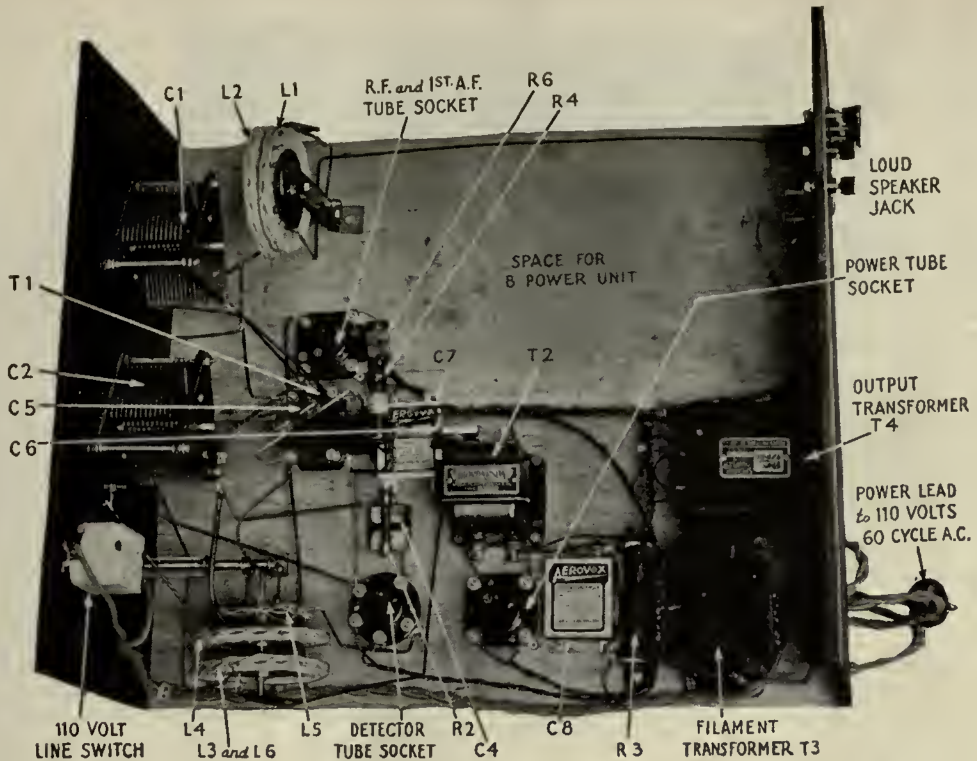
FIG. 2

Circuit diagram of the crystal set and one stage of audio amplification. The insert shows how the detector bias may be obtained from the voltage drop in the rheostat

THE LIST OF PARTS

The experimenter who already has odds and ends of radio apparatus in his possession can probably assemble the receiver described here without the purchase of much additional apparatus. The parts listed below were used in the receiver described, although of course any others, electrically and mechanically similar may be selected.

C_1—Remler 0.0005 mfd. type No. 639 condenser Remler standard dial
L_2—52 turns No. 24 s.c.c. copper wire wound on 3″ form
L_1—10–20 turns No. 28 o.s.c. copper wire
T_1—General Radio No. 285 audio transformer
R_1—Frost 30-ohm rheostat
Carborundum Company detector unit
Frost UX type socket
Fahenstock spring clips (8)
One—UX-199 vacuum tube
One—Westinghouse Micarta panel
One—Wood baseboard
3—dry cells
One—set Trimm headphones



THE EVER-POPULAR ROBERTS SET WITH A. C. OPERATION

The illustration is lettered to agree with the list of parts on page 101 and with Fig. 3. The circuit diagram. This model of the a.c. Roberts reflex circuit was built to fit in a phonograph cabinet. It is unnecessary for the constructor to follow this layout for wide latitude is allowed by this circuit in this respect

A Three-Tube A. C. Operated Roberts Receiver

By ELMER G. HERY

OF THE thousands of set-builders who have constructed the original three-tube Roberts, few have been won over to any other circuit unless they have gone to a much more elaborate and expensive layout. For those who know the merits of the Roberts circuit, a.c. operation as described in this article is almost inevitable.

Beginners will find in this receiver a set which is easy to construct and uniformly excellent in results as to the quality, selectivity, sensitivity, volume, and distance reception.

An important feature is that this circuit does not require the most expensive pieces of equipment. It may be constructed from whatever materials are at hand. The skeptical may make a rough assembly of old parts, and then convince himself that the substitution of any good low-loss parts will give better results. [The list of parts and the photographs show exactly what was used in the set described by the writer. The parts are all standard and readily available. Wide substitution can be made, according to the desire of the constructor.—*Editor.*]

Another good feature is the fact that the arrangement of parts and the panel shape do not affect the results. This circuit has been built by the writer on square panels and on long narrow panels, and to fit in all kinds of cabinets with excellent reception in all cases.

The first thing to consider is the coils. Manufactured coils may be used if desired. The writer has used Sickles and Hammarlund-Roberts with perfect satisfaction. If the set-builder desires to make up his own coils they can easily be made. Thirteen-point spider-web fiber forms are required. They may be obtained from the 10-cent stores. The antenna coil consists of thirty-five turns wound over-two-and-under-two spokes, with a twisted loop or tap every five turns. There are two secondary coils L_2 and L_4, and each consisting of forty-four turns wound over-two-and-under-two spokes. The tickler coil, L_6 consists of twelve turns wound over-two-and-under-two spokes. These four coils are all made of No. 22 double cotton covered wire. The NP coil L_3, is made of No. 26 double cotton covered wire. This coil consists of a double winding; that is, two parallel wires wound over-one-and-under-one spoke, with eighteen turns. In other words, there are two concentric coils of eighteen turns each. The wire may be twisted or kept flat, preferably the latter.

The A. C. Roberts Receiver

THE Roberts receiver, first introduced by RADIO BROADCAST *in 1924 won many friends for radio and many for this magazine. It has been constructed by more than 100,000 radio fans and, in one form or another, is still giving satisfactory service all over the world. The circuit is so efficient—considering the number of tubes employed—and so easy to build and operate that its popularity, like a certain famous cigarette, is deserved. Many readers are still interested in building the circuit and Mr. Hery's article here gives them full instructions and a wide latitude in construction. For those who are interested in making over their present Roberts set for a.c. operation, the last part of this article provides sufficient information. The circuit shown here employs the original reflex arrangement. Those who desire to employ a straight audio stage and eliminate the reflex may secure information by writing to our Technical Information Service.*

—THE EDITOR.

The antenna coil and its secondary coil are mounted on the same shaft about $\frac{1}{8}''$ apart. A long brass machine screw ($3\frac{1}{2}''$ or more) makes an ideal mounting arrangement, using a nut on either side of each coil to hold it rigid. The machine screw is bent to give any desired mounting angle to the coils, and fastened through the baseboard with a nut. (See Fig. 1) Fig. 1-B also provides a very simple mounting through one of the spokes of one coil.

A standard mounting for the tickler coil is an arm with knob for panel mounting. The NP and secondary coils may then be mounted on a screw through the baseboard as shown in Fig. 2. The dotted lines show the tickler coil in the raised position.

It is important that the antenna coil and its secondary be mounted so that the direction of rotation of the windings is the same for both coils. Likewise the NP, Secondary, and Tickler coils should be wound in the same direction. One way to avoid trouble from this source is to proceed as follows: when the coils are wound, mark on the forms an arrow which points around the form in a clockwise direction. Then, starting from the inside and proceeding to the outside of the form, the wire should be wound

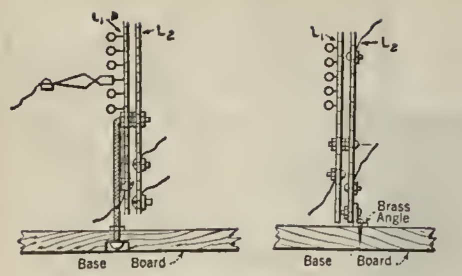


FIG. 1A-B
Details for mounting and tapping the coils

on in a clockwise direction. The coils in each assembly should be arranged so that all of the arrow marked sides face in the same direction. The two groups of coils should be mounted as far apart as mechanically possible, and at right angles to each other.

After the coils have been mounted and the positions of the other pieces of equipment have been determined, the inside and outside leads of each coil may be brought to the most convenient spoke of the spider-web form, and fastened through a hole in the spoke by means of a screw and nut (see diagrams). Then the spokes may be cut off to within $\frac{1}{8}''$ of the wire on the coil, thus reducing the over-all size of the coils. For connections, the outside and inside leads of coils are indicated on the wiring diagram by "O" and "I" respectively. The center point of the NP is coil indicated by "M." The coils as they appear on the wiring diagram, Fig 3, from left to right are as follows: Antenna, L_1, antenna secondary, L_2, NP, L_3, and L_6, secondary, L_4, and above the secondary, the tickler coil, L_5.

The taps on the antenna coil may be connected to an inductance switch if desired, but a simpler method is to place a test clip (See Fig. 1A) on the end of the ground lead, and clip to the tap which gives the best results. The longer the antenna in use, the fewer turns will be required on the antenna coil. One tap will be found which will give satisfactory results on all wavelengths.

The method of obtaining the mid-point "M" of the NP coil may require some explanation. "M" is obtained by connecting the inside end of one winding with the outside end of the other winding. Two different colors of wire may be used to avoid confusing the two windings, or a flashlight bulb may be lighted through each winding to locate the corresponding inside and outside ends.

LOCATING THE APPARATUS

THERE is nothing special to be said about the locating or mounting of the remaining equipment, with the exception, of course, that the grid and plate leads should be kept short. The photographs give an idea of a good baseboard layout which was designed to fit a phonograph cabinet and to include all the a.c. power supply apparatus. The panel layout suggested may easily be modified to suit the size and shape of the panel used by the constructor who duplicates this receiver.

The switch mounted on the panel controls the line current supply and should be of a size and capacity equal to wall switches used for house lighting. A simple method is to use the body of any ordinary 110-volt tumbler switch and mount it directly on the panel with a slot cut in the panel for the lever.

No rheostats are needed when the a.c. tubes are used, and the volume control may be a 25,000-ohm potentiometer in the antenna circuit or the volume control may be as indicated in the model described here, i.e., a variable resistance such as a Clarostat or Bradleyohm across the secondary of the first audio transformer. No loud speaker jack is shown on the panel, as modern practice tends toward mounting this at the back of the set if it is used at all, with the antenna and ground binding posts.

As to the make of tubes to be used, there is little choice between standard, reliable products. There has been considerable doubt on the part of prospective set-builders as to whether the a.c. tubes will give very long usage. For those who prefer to make certain, a written guarantee is given with some makes to replace tubes free of charge if they fail to function for one year. This should satisfy the demands of the most exacting buyer. This article describes the use of a.c. tubes which employ the Radiotron type bases, although the set will work excellently with the Sovereign or Kellogg a.c. tubes. In the event that the builder uses this type of tube, the major difference between that construction and this is in the a.c. filament circuit.

No rules need be observed in the assembling of the set, except that the filament leads should be isolated as far as possible from all other leads, and especially from grid leads. The photographs show how this may be accomplished. It is undoubtedly wise to complete all other wiring of the set before starting the filament wiring, to avoid any possibility of connecting filament leads to any other part of the circuit.

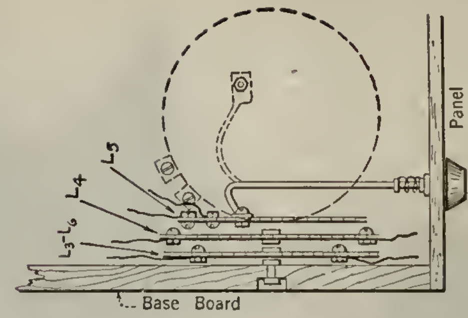


FIG. 2
The coils and their relation to the panel

The filament current may be obtained from a filament transformer. If a 112 or 171 type tube is to be used for the last amplifier, the filament transformer should have three voltages; namely, $1\frac{1}{2}$ volts, $2\frac{1}{2}$ volts, and 5 volts. Some B power units provide a 5-volt winding which may be used for the amplifier tube, in which case only the two lower voltages need be supplied by the filament transformer. If a 210 type tube is used for an amplifier $7\frac{1}{2}$ volts are required for the filament, and this voltage is usually provided in the power pack or powerizer being used for plate current.

Any good filament transformer may be used, some makes furnishing mid-taps for the $2\frac{1}{2}$-volt and 5-volt windings. It is not wise to use a mid-tap in the transformer on so low a voltage as $1\frac{1}{2}$, so that instead a mid-tap resistance or a potentiometer, R_6, is used to obtain the mid-point of the $1\frac{1}{2}$-volt winding. The mid points of the $2\frac{1}{2}$-volt and 5-volt windings may be obtained in the same manner if the transformer is not provided with mid-taps.

SECURING GRID BIAS

FOR grid bias on the reflexed tube, the center point of the mid-tap resistance is connected to one side of a 1000-ohm resistor, R_4, The other side of the resistor is connected to ground and there is a 1.0-mfd. condenser, C_7, across the resistor. For grid bias of the power tube, the mid-tap of the filament transformer winding supplying this tube is connected to a resistance of 2000 ohms, R_3, the other side of which is connected to ground. A 1.0-mfd. condenser C_8 is placed across this resistance. This value of resistance is satisfactory for 112 and 171 type tubes.

Some tube manufacturers recommend a positive grid bias for the heater of the detector tube, and some recommend negative bias. In this circuit no bias has been found necessary. The mid-tap lead of the $2\frac{1}{2}$-volt winding may be connected to plus 45 instead of to ground in the event that there is excessive hum in the output of the receiver.

A 227 type tube may be used in the reflex position if desired, but satisfactory results should be obtained with the 226 type, and this type is somewhat cheaper than the 227 type.

Each pair of filament leads must be twisted with about two or three twists to the inch to avoid hum. Likewise, the leads which go to the tumbler switch on the panel should be twisted, as well as any other a.c. leads in or around the set. For filament wiring, no smaller wire than No. 14 should be used, as the a.c. tubes draw a much heavier current than the d.c. tubes. For

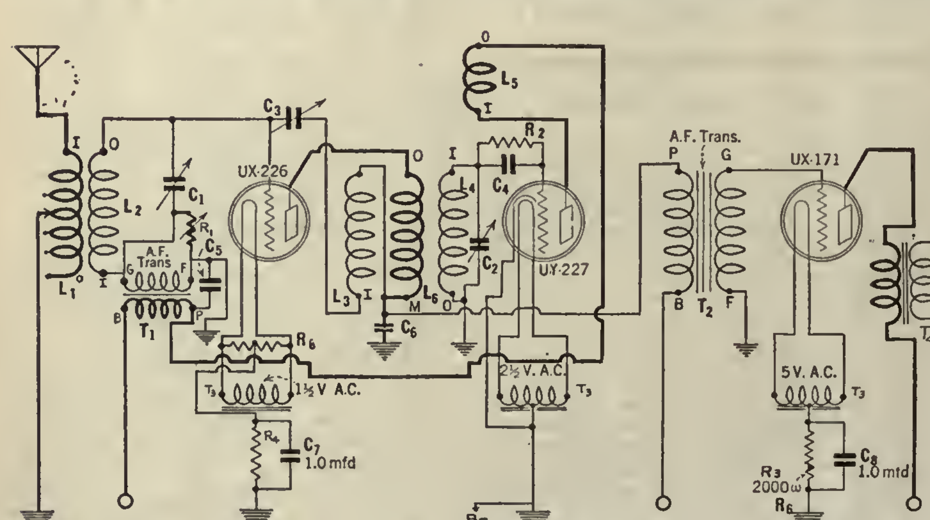


FIG. 3
Diagram of connections. Those who desire to convert their d. c. Roberts sets can follow this diagram and instructions on this page and the one following

wiring the balance of the set Celatsite or similar hook-up wire is recommended.

CONVERTING YOUR D. C. ROBERTS

FOR the conversion of a storage-battery-operated Roberts set to complete a.c. operation, the wiring diagram and the instructions already given are perhaps sufficient. The substitution of a B- power unit for a B battery needs no explanation. Obtaining grid bias without C batteries, though sometimes confusing, should be clear from the diagram. A C-battery in the grid circuit puts the grid voltage below the filament voltage, whereas a resistance between the filament circuit and ground places the filament voltage above the grid voltage. The effect is the same in either case. The C batteries may first be removed and connections made in their place as shown in the diagram. Next, the filament leads of each tube in the d.c.-operated set may be increased in size if necessary to carry the heavier current taken by a.c. tubes. [Wire tables showing current carrying capacity will give this information. Or see RADIO BROADCAST Laboratory Information Sheet No. 141, November, 1927, issue.—*Editor*.] Care must be taken in this changeover to a.c. not to remove any leads which serve some purpose other than lighting the d.c. filaments. A "UY" socket may now be substituted for the UX socket in the detector position, and the same grid and plate leads that were connected to the UX socket go to the UY socket. If an output transformer or filter is not in use, one should be installed as shown.

In the list of parts given here, some names of equipment are mentioned because of successful experience with these makes. Perhaps other makes will give equally good or even better results, but some experimenters often like to have something definite in mind when they do their purchasing. In the case of the variable condensers, a rugged low-loss construction such as General Radio is strongly recommended. The parts required for conversion of the d.c. set to a.c. are indicated separately at the end of the list.

THE ALL IMPORTANT CONTROLS ARE HERE

The values given for fixed condensers, resistances, etc., will generally be found satisfactory, but they may be experimented with after the set is in operation, for possible improvement to suit the taste of the user.

LIST OF PARTS USED

- C_1, C_2—General Radio 0.0005-mfd. variable condensers.
- C_3—Hammarlund 9-plate neutralizing condenser.
- C_4—Dubilier 0.00025-mfd. fixed condenser with clips.
- C_5—Dubilier 0.0005-mfd. bypass condensers.
- C_6—Dubilier 0.0025-mfd. bypass condenser.
- C_7, C_8—Aerovox 1.0-mfd. bypass condensers.
- R_1—Clarostat volume control resistor.
- R_2—Tobe Tipon grid leak (about 2.0-meg. although various values should be tried).
- R_3—Hardwick-Field C-bias resistor, 2000-ohms.
- R_4—Ward-Leonard C-bias resistor, 1000 ohms.
- R_6—General Radio center-tapped resistor.
- T_1—Amertran AF-6, 5:1 audio transformer.
- T_2—Thordarson R-200 audio transformer.
- T_3—Acme Apparatus AC-2 filament transformer.
- T_4—Bremer-Tully output device.
- —Frost open-circuit jack.
- —General Electric tumbler switch.
- 5—Spiderweb coil forms and 2 coil mounting arms.
- —Wire for coils: ¼-lb. No. 22 d.c.c.; ⅛-lb. No. 26 d.c.c.
- 2—Benjamin UX sockets.
- 1—Benjamin UY socket.
- 2—Marco dials.
- 5—Eby binding posts.
- —No. 14 lamp cord for a.c. circuit.
- —25 ft. Celatsite hook-up wire.
- Test clips, screws, nuts, baseboard, and Westinghouse Micarta panel.

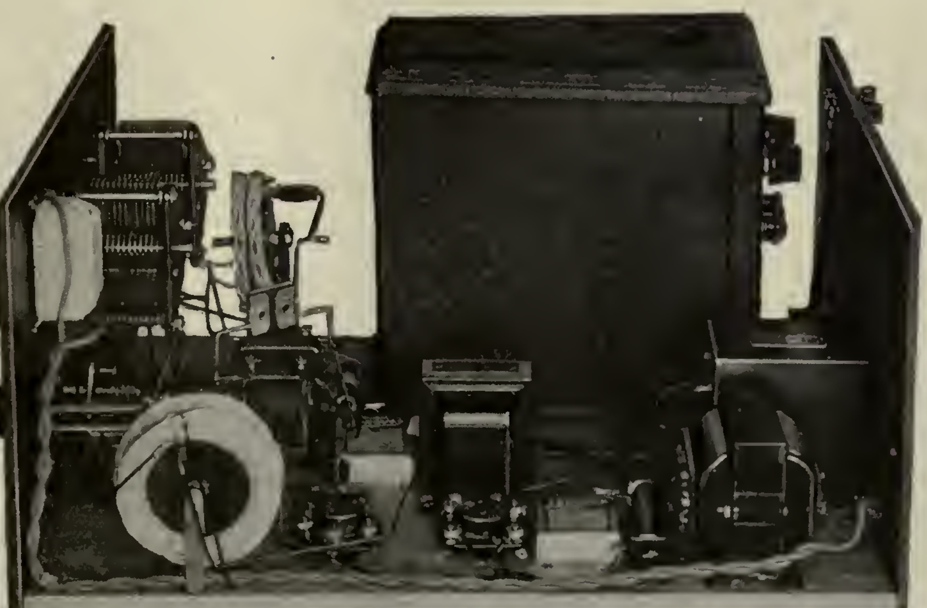
ADDITIONAL PARTS

- 1—B-power unit supplying the following voltages: 45, 90, 135, 180
- 1—Type 227 a.c. tube
- 1—Type 226 a.c. tube.
- 1—Semi-power tube, either 112 or 171 type

The coils used in the set described are home-constructed according to directions in the article. Sickles or Hammarlund-Roberts coils may be used if the builder prefers to use manufactured coils.

The circuit and building instructions deal with the 226 and 227 type of a.c. tube although as indicated in the article, the Sovereign or Kellogg heater type a.c. tubes can be employed equally well if the constructor makes the necessary filament circuit and mechanical changes required.

If one has on hand a d.c.-operated Roberts receiver which is to be changed over to a.c. operation, it will of course be possible to use in the revised set most of the parts contained in the d.c. model. Only the following items in the above list of parts need be purchased, in changing a set from d.c. to a.c. operation: C_7, C_8, R_3, R_4 R_6, T_3, one Y type socket and a line switch.



THE BASEBOARD ALLOWS ROOM FOR A B-POWER UNIT
This provides complete a.c. operation with maximum simplicity

AS THE BROADCASTER SEES IT

BY CARL DREHER

The Simplest Receiver

On a recent visit to KDKA I had demonstrated to me the simplest and most inexpensive radio receiver in the world. Although generally cautious in the use of superlatives, in this case I use them without fear of contradiction. The cost of the receiver in question is precisely nothing. It is exceedingly compact; you could hide it under either half of your mustache, although it might not be convenient to keep it there. It is portable; you can carry it around the house, or outside, set it up in an instant, and when you don't want it, it disappears. It provides a loud speaker signal of moderate intensity. The loud speaker is contained in the set. There are no knobs, tuning controls, or adjustments of any kind; a child can operate this receiver just as well as a radio engineer. It requires no antenna and no battery or power supply of any description. The maintenance cost, it follows, is nil. In these respects it is certainly the ideal broadcast receiver.

It has only two faults, which, in all honesty, I shall now reveal. It will not receive any other station than KDKA. The tone is decidedly thin.

The technical gentlemen of the Westinghouse Company can produce any reasonable number of these radio receivers on the transmitter grounds on a moment's notice. All they do is to pick up a nail or piece of metal and touch it to a spike in one of the wooden poles which support the antenna. Withdrawing the bit of metal slightly, the experimenter pulls out an arc a quarter or half inch long. He is thus drawing out of the air, according to orthodox radio principles, a few watts of the fairly considerable number which KDKA is flinging prodigally over the Pennsylvania hills. As this radio-frequency arc is modulated, it sings shrilly in accordance with the voice or music which is agitating the KDKA carrier at the moment. It is a radio receiving set, with all the virtues that I have claimed for it. And when you are through with it you toss the nail away.

This receiver possesses one other convenience which, as far as I know, is incorporated in no other instrument of its class, and is found lacking even in $3000 outfits built for barons and millionaires. You can light a cigarette with it!

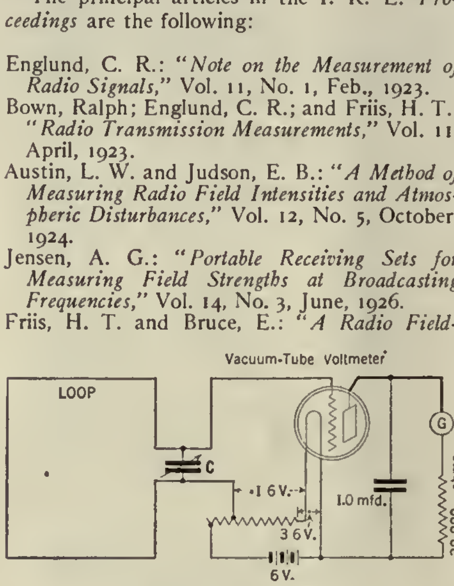
Operation of Broadcasting Stations

20. FIELD STRENGTH MEASUREMENTS

Most operators of broadcast transmitters have only the vaguest sort of idea of what their outfits are actually doing, in the way of providing a signal for listeners, even in their immediate neighborhoods. A broadcasting station depends on its listeners just as much as a newspaper depends on its readers, or a gas or electric power company on its customers. The newspaper comparison is closer from the practical commercial angle, while physically the gas or power company analogy is quite exact. The broadcast transmitter must provide a certain radio-frequency pressure for the listeners whom it wants to reach, just as the gas company must maintain a certain gas pressure if it wants to sell gas, and the electric power concern must keep a fixed electric potential between its wires. The difference is that the power and gas companies know what that pressure is, whereas the broadcaster generally does not. Yet there is no great mystery about the matter. The field intensity of a radio transmitter can be measured, not as simply as gas and electrical pressures, but with an amount of cost and trouble which is certainly not prohibitive considering the fundamental importance of the knowledge gained and the fact that a large investment is often involved. Every broadcast technician should at least know the general theory of field intensity measurements and calculations.

The principal articles in the I. R. E. *Proceedings* are the following:

Englund, C. R.: "*Note on the Measurement of Radio Signals,*" Vol. 11, No. 1, Feb., 1923.
Bown, Ralph; Englund, C. R.; and Friis, H. T.: "*Radio Transmission Measurements,*" Vol. 11, April, 1923.
Austin, L. W. and Judson, E. B.: "*A Method of Measuring Radio Field Intensities and Atmospheric Disturbances,*" Vol. 12, No. 5, October, 1924.
Jensen, A. G.: "*Portable Receiving Sets for Measuring Field Strengths at Broadcasting Frequencies,*" Vol. 14, No. 3, June, 1926.
Friis, H. T. and Bruce, E.: "*A Radio Field-Strength Measuring System for Frequencies up to Forty Megacycles.*" Vol. 14, No. 4, August, 1926.



Size of loop, 103 cm. square
No. of turns, 5
Inductance, 77 microhenries
Resistance, 3.5 ohms

FIG. 1

For those who do not wish to consult the sources listed above a brief outline of the subject is presented here.

A transmitting antenna, with a certain amount of radio-frequency current flowing in it, sets up a moving field of electric force which is expressed in volts per meter, or in some more convenient units, such as millivolts or microvolts per meter. This simply means that if a receiving antenna is put up within range it will be charged by that field to a certain radio-frequency potential for each meter of its electrical height. The field strength of a 5-kw. broadcasting station, about ten miles away across fairly good transmission territory, may be of the order of 30 millivolts per meter, to give a practical illustration. Then if a listener puts up an outdoor antenna with an electrical height of 3 meters, he will get 90 millivolts from that transmitter to put into his receiver. The electrical height is less than the physical height (one-half is a common ratio). It is a measure of electro-magnetic effectiveness in transmission and reception. Its meaning may be better understood after a study of the basic absorptionless transmission formulas:

$$I_r = 120\,\pi\,\frac{I_s h_r h_s}{\lambda\, d\, R} = 40 \times 10^{-5}\,\pi\,\frac{I_s h_r h_s f}{d\, R} \qquad (1)$$

where I_r is the received antenna current in amperes, I_s the transmitter antenna current in amperes, λ wavelength in meters, f the frequency in kilocycles, h_r the effective or electrical height of the receiving antenna, in meters, h_s the effective height of the transmitting antenna, in meters, d the distance in meters between the antennas, and R is the resistance of the receiving antenna.

The transmitting current may be measured by means of a thermo-ammeter in the base of the antenna. The wavelength and frequency are known, if only because the Federal Radio Commission and the Department of Commerce insist on quite accurate data on this point. The resistance of the receiving antenna at the particular frequency in question may be measured by the added resistance method. (See Circular of the Bureau of Standards, No. 74. "*Resistance Measurement.*") The distance d is a factor which may be set by placing a receiver a few wavelengths from the transmitter, and then I_r will be sufficiently high so that it may be measured in the receiving antenna directly by means of a thermo-galvanometer or thermo-milliammeter, or the voltage across a receiving loop may be found by means of a vacuum-tube voltmeter. Thus the product of the two effective antenna heights, h_r h_s may be calculated from (1), rewritten as follows:

$$h_r h_s = \frac{10^5\, d\, R\, I_r}{40\,\pi\, I_s\, f} \qquad (2)$$

Of course this does not give us either h_r or h_s individually. As stated before, h_r may be approximated by taking half the physical height of the flat-top of the receiving antenna above ground, if it is well removed from absorbing objects. Or, in the case of a loop antenna, it may be calculated by a formula which is derived from our knowledge of the mechanism of radio transmission and the nature of radio-frequency pick-up by a loop or coil antenna, which responds to the electro-magnetic component of the wave. With the loop turned end-on to the direction of radiation, and the antenna effect disregarded, the effective height is given by:

$$h_r = 2\,\pi\,\frac{\text{Area} \times \text{Number of Turns}}{\lambda} \qquad (3)$$

Thus h_r and h_s may both be determined.

The quantity h_s is also of importance in that it is a measure of the radiating efficiency of the transmitting antenna. This radiation resistance, as it is called, is a part of the total resistance of the antenna. An antenna, like any other energy-converting device, has losses. The ohmic or heat loss incidental to currents flowing in a conductor is one of them. Then there are dielectric losses in the ground or in objects near the antenna. These are actual losses of energy similar to the losses caused by windage, winding resistance, and mechanical friction in an electric motor. But an antenna is peculiar in that it has one type of loss of energy which it is definitely designed for, which is its reason for existence. It radiates energy, which is purposely lost so that it may be picked up elsewhere for the communication of intelligence. The total power dissipated in the antenna is given by:

$$P_t = I_s^2 R_t \qquad (4)$$

The radiated portion is given by:

$$P_r = I_s^2 R_r$$

$$R_r = 1600 \frac{h_s^2}{\lambda^2} \text{ Ohms} \qquad (5)$$

where R_t is the total transmitting antenna resistance, R_r is the radiation resistance, and h_s and λ are in the same units of length. Thus when we have determined the radiation resistance of the transmitting antenna by the procedure which is outlined by formulas 1 to 5, we have some idea of the energy radiated by the transmitting antenna, which means that we know the fundamental quantity in the physical functioning of the station when it is "on the air," We know how much of the power we put into it is getting away from the station.

A practical little summary of work in field intensity determinations is the pamphlet by R. O. Cherry, prepared under the direction of Professor T. H. Laby, on *"Signal Strength Measurements of 3LO, Melbourne."* The measuring set consisted of a loop, a tuning condenser, and a thermionic voltmeter to measure the potential induced in the loop by the broadcasting station. The voltmeter was an instrument of the Moullin type, manufactured by the Cambridge Instrument Company, using plate rectification to cover a scale of 0-1.5 volts. Cherry's pamphlet does not show the voltmeter circuit, but this has been reproduced in Fig. 1 of the present description, from page 35 of Moullin's *"The Theory and Practice of High-Frequency Measurements"* (Charles Griffin & Co., Ltd., London), an excellent work which has been reviewed in this magazine. Moullin's Fig. 25, added to Cherry's Fig. 1, gives us our Fig. 1. In the manufactured form of the instrument the plate battery is dispensed with and the 1.6-volt negative grid bias is secured from the 6-volt battery used to light the filament of the tube. Aside from this battery the voltmeter is self-contained. The calibration is stated to be independent of frequency and the galvanometer reads directly in volts, 1.5 volts r. m. s. being full-scale. When the applied potential difference exceeds 0.4 volt, grid current flows at the peak of the positive half cycle, and the instrument draws a slight amount of power, the apparent resistance at full scale being of the order of 0.75 megohms, corresponding to a power absorption of 2.5 microwatts. The voltmeter is used with British valves intended for a 4–5 volt filament potential, which is reduced to 3.5 volts in this case, thereby prolonging the life of the valve and the calibration of the voltmeter, barring accidents, almost indefinitely.

The 3LO report starts off with Formula (3) of the present discussion, followed by an expression for the field strength, whose equivalent is:

$$E = \frac{V}{h_r \sqrt{1 + \frac{w^2 L^2}{R^2}}} \qquad (6)$$

where E, in volts per meter, is the field strength at the point of reception; V, in volts, is the potential difference measured across the loop; h_r, in meters, is the effective height of the loop $w = 2\pi f$, where f is the radiated frequency; L is the inductance of the loop in henrys; and R is the high-frequency resistance of the receiving circuit, at the frequency f.

It is easy to see how, according to (6) the field strength, by definition, will equal the received voltage divided by the effective height of the receiver, but the origin of the square root factor may not be clear. Cherry gives no explanation, so it may be added that the expression without the added factor would be true for an open loop picking up a voltage from the transmitting station in question, but in practice it is necessary to tune the loop, as shown in Fig. 1, both in order to select the e. m. f. from the desired station, and in order to get enough voltage to measure. But then we are measuring the resonance e. m. f. of the loop circuit, and this must be corrected by $\sqrt{1 + \frac{w^2 L^2}{R^2}}$ before we can deduce the field strength.

The next step is to measure or calculate the inductance of the loop. For the calculation process the reader is referred to the Bureau of Standards circular cited above. If a calibrated local oscillator is available, and the condenser across the loop also has a known calibration, the distributed capacity of the loop may be determined, and the inductance is then easily calculable from the wavelength formula:

$$\lambda = 1.885 \times 10^6 \sqrt{LC} \qquad (7)$$

where C is the total capacity (loop capacity plus condenser capacity).

Fig. 2 shows a curve of wavelength against various capacities of the tuning condenser when the loop circuit is tuned to different frequency settings of the oscillator coupled to it. The line being extrapolated, the point where it cuts the X-axis (zero wavelength) gives the distributed capacity of the loop. In the case of the 3 LO experiment the wavelength was 371 meters, and the loop capacity was found to be 65 micro-microfarads, which, added to the condenser capacity for resonance, gave a total capacity of 505 micro-microfarads, whereupon substitution in (7) gives:

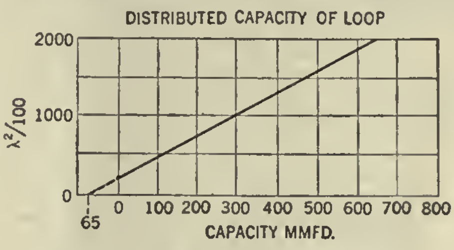


FIG. 2

$$371 = 1.885 \times 10^6 \sqrt{L \times 505 \times 10^{-12}}$$

$$L = 7.698 \times 10^{-5} \text{ Henry}$$

$$= 77 \text{ Microhenrys}$$

The resistance of the loop, condenser, and voltmeter circuit must also be measured. Cherry gives the procedure, but instead of repeating it I shall refer those who have a practical interest in the problem to *Circular No. 74* again. The mean of several measurements in the particular example we are following was 3.5 ohms. A source of inaccuracy which must be considered at this point is that the resistance of the thermionic voltmeter is not quite constant, introducing a variable loss, which Cherry believes is between 0.5 and 0.9 ohm equivalent series resistance. This will result in a slightly low value for the higher field strengths, but as such measurements, made with a loop, are not good to better than 5–10 per cent., a mean value for the high-frequency resistance of the receiving circuit is sufficient for practical purposes.

All the other quantities needed for the calculation, first of the effective height of the loop (Formula 3), then of the field strength (Formula 6), are known. Using Formula 3, we may write:

$$h_r = 2\pi \frac{(1.03)^2 (5)}{371}$$

both the length of the side of the loop, which, squared, gives the area, and the wavelength, being expressed in meters; the result gives h_r, also in meters, as 0.090. To get E from (6) we must find the value of $\frac{wL}{R}$; w is $2\pi f$, and f is the frequency corresponding to a wavelength of 371 meters; this may either be looked up in a wavelength-frequency table or calculated from the basic relationship that the frequency is the velocity of light (3×10^8 meters per second) divided by the wavelength, whence:

$$w = 2\pi \frac{3 \times 10^8}{371} = 5.08 \times 10^6$$

$$\text{and } \frac{wL}{R} = \frac{(5.08)(10^6)(77)(10^{-6})}{3.5} = 112$$

$$\text{So finally we get } E = \frac{V}{(0.09)(112)} = \frac{V}{10.1}$$

This gives us the field strength in terms of the reading of the thermionic voltmeter, divided by a substantially constant factor, as long as the same loop, condenser, and voltmeter are used, and the wavelength remains the same. The loop, of course, is turned to secure a maximum deflection for each observation. If the apparatus were to be used for only one station, the wavelength of which is fixed, the voltmeter scale could be arranged to read the field strength directly.

In the case of 3 LO, the following field strengths in m/v per meter were found, using the procedure outlined:

Distance	Direction		
	North	*East*	*West*
1 Mile	400	250	200
5 Miles	90	60	50
10 Miles	45	30	25

From such data it is possible to draw contour maps of the field pattern of a station, such as those secured in the elaborate investigation of the distribution of WEAF and WCAP (Bown and Gillett: "Distribution of Radio Waves from Broadcasting Stations over City Districts," *Proc. I. R. E.*, Vol. 12, No. 4, August, 1924). Bown and Gillett used one of the short-wave measuring sets developed by Bown, Englund, and Friis, and with this more elaborate apparatus were able to get down to field strengths of the order of a fraction of a millivolt per meter; some of their curves extend to a distance of over a hundred miles from the transmitter. The simple apparatus described by Cherry is, of course, restricted to a much smaller radius, but it illustrates the principles involved just as effectively. The contour lines in the case of 3 LO form a group of quite regular concentric ellipses, which would be expected with the transmitter located in fairly open country. The pattern from a station located, like the old WEAF, in the heart of a city like New York, is far more irregular, naturally.

Within the radius of neglectable absorption the product E_d (field strength times distance from transmitter) is approximately a constant; this relation may be used as a check on the accuracy of the field strength measurements.

Goldsmith ("Reduction of Interference in Broadcast Reception," *Proc. I. R. E.*, Vol. 14, No. 5 October, 1926) gives the following table of program service as a function of field strength:

Signal Field Strength	Nature of Service
0.1 millivolt per meter	*Poor service*
1. millivolts per meter	*Fair service*
10. millivolts per meter	*Very good service*
100. millivolts per meter	*Excellent service*
1000. millivolts per meter	*Extremely strong*

Edgar Felix has pointed out that the commercial value of a broadcast transmitter, other things being equal, is a function of field distribution. This is true, and, when the owners of stations realize it, more field strength measurements will be made in divers neighborhoods. If the field strength is not being produced in the sections where it is wanted, the artists and the advertisers might as well go home, and the studio be converted into a salesroom for artificial flowers.

The limitations of space will not permit a longer technical discussion of the subject. Readers who are interested beyond this point are again referred to Moullin's book, in which Chapter VIII (pages 218–254) is devoted to a thorough study.

The Listener's Point of View

HOW CAN GOOD RADIO PROGRAMS BE CREATED?

By JOHN WALLACE

IN THIS department last month we proposed the question "Can the Broadcaster Improve Broadcasting?" and averred that in our opinion he could not and that the time was ripe for him to call in outside help. The suggestion is a sound one and we are further confirmed in our conviction of its essential truth by our discovery that the same idea occurred, at almost the identical time, to several other professional reformers of radio.

Since we think the point is an important one and worth acting upon, and since it is best emphasized by repeating it, we quote from two other scribes. Mr. Zeh Bouck, in his estimable column in the New York *Sun* said in part:

"Our asseveration that the program departments of large broadcasting companies were, in principle and practice, incapable of turning out more than a small percentage of meritorious programs—originality, interest, intelligence and esthetics being the criteria of merit—has aroused a certain amount of controversial interest. The question arises, if the program departments of the large broadcasting companies should, as we have suggested, be eliminated in some relatively painless manner, who, then, should prepare the programs? Or rather, let us say, conceive the programs, for the actual preparation, the manual labor, could still be left to the studio hacks. There remain three possibilities. The advertiser can prepare his own programs, making broadcasting a section of his advertising department. Second, the advertising agency is a logical consideration, preparing material for broadcasting in a manner comparable to the preparation of printed advertising. Both of these systems are in operation to-day, and are producing programs notably superior to the rubber stamp variety turned out by the broadcast organizations themselves. . . .

"On the other hand, the program department of the large broadcasting organization, turning out programs by the hundreds, fitting a Swiss cheese classic and a rather extenuated ode to Persian rugs into pretty much the same skeleton after the manner of Martin Eden writing his pot boilers, necessarily exhibits the creative talents of a child making mud pies.

"There is still a third possibility which we originally suggested a few weeks ago, namely, the purchase by the broadcasting company or advertising agency, for that matter, of ideas and radarios submitted by free lances, in much the same manner that stories are submitted and bought by magazines. In this manner, a wealth of new material and ideas would supplement the rather wornout traditions of radio Cook's tours and songs of yesteryear.

"These ideas, and the radarios themselves when necessary, could be readily adapted to broadcasting by the station organization, which is often as adept in the mechanics of broadcasting as it is inept in creative brilliance."

Mr. Morris Markey, not a professional observer of radio, but a writer of special articles, leaped immediately to this same conclusion in a story written recently for the *New Yorker*.

"A small amount of work is being done among the four hundred employes of the National Broadcasting Company in the way of experimental programs. There have been hesitant, and on the whole unsuccessful, efforts to create visual images, of setting and atmosphere, through the loud speakers. And there have been sporadic trials of dramatic episodes, snatches of plays and such. But like most enterprises organized solely for the pursuit of money, the broadcasting industry is conservative. An experiment itself, it looks upon experiment in the entertainment it provides as something to be avoided. It has failed to recognize that radio has thus far produced not one suggestion of showmanship. It has failed to observe that the showmanship of the microphone, when once it is developed, will be a vastly different thing from the showmanship of the camera or the stage. The employes whose duty it is to keep the performance going are, in the large part, hacks. They are routine men who are not hired for imagination or invention, but for their ability to fill every hour on the air with something or other, preferably of a revenue-producing nature. There is not in all the radio world a figure comparable to the producer in the theatre or the director in the movies—and most of the gods of the trade are unconscious, apparently, of their need for such a figure. Vaguely it is realized that something will have to be done about the programs, but few in the industry appear to understand that these programs must have the touch of a creative person upon them."

How Long Can the Ballyhoo Last?

THE second big splurge of the Dodge Brothers Company, its much touted Movie Star Hour turned out to be "just another program." The foregoing review is a decidedly unfair one, for at the time we write, the program referred to has not yet taken place and will not for several days. It is to be made up—or at the time you read this, was made up—of the voices of Norma Talmadge, Charlie Chaplin, Douglas Fairbanks, D. W. Griffith, John Barrymore, and Dolores del Rio. It required the usual million miles or so of telephone wires, the conventional thousand or so engineers, and of course the trillion or so dollars of investment and commanded the listening attention of every man, woman, and child in the United States over the age of thirteen months. And it served to convince this particular reviewer that most of the individuals heard had selected their profession with great wisdom and ought to be encouraged to stick to the silent drama. Mr. Barrymore, to be sure, contributed an excellent reading of the Hamlet soliloquy, but the only reward for listening to the others was a satisfied curiosity concerning the pitch of their voices.

AMOS 'N' ANDY; ALIAS CORRELL AND GOSDEN

The former "Sam 'n' Henry" team so popular with listeners to WGN have transferred their attentions to the microphone of WMAQ of Chicago where they are heard nightly at 7:11 P.M. central time, except Sunday and Wednesday

Just to show us up as an inaccurate prognosticator, that program may turn out to be a wow. But it hardly seems likely. There is no reason to expect that because Norma Talmadge is perfectly entrancing on the screen her voice is going to prove anything in our parlor. We would be far more willing to lay a wager with Lloyd's that she will be a fizzle. But we don't intend to write indignant letters to the sponsoring company arguing this point for they are just as aware of it as we are. Our opinion of their fancy program, and indeed the opinions of any of our fellow scribes, mean quite nothing at all to them. And rightly so: they are not concerned with devising a good radio program but with getting something up to ballyhoo. They have craftily selected six of the biggest names in the movie world. They will get countless miles of newspaper space, probably not only in the radio sections, but perhaps in the movie sections as well, and even in the news columns and editorial pages. In other words, though it costs them a fortune to hire the movie stars and the broadcasting facilities, they will probably get more newspaper space than they could have paid for with ten times the sum, and they'll get the air advertising to boot.

Nobody, not even the querulous critics, actually got riled about their thousand-dollar-a-minute Victory Hour; we were all too bowled over with admiration of the really beautiful advertising *coup* that it was. But nobody pretends that it ranked very high in entertainment. In a list of the best programs of the year it would have placed well down in the second hundred. The movie star hour will probably take even lower rank.

The two programs mentioned have not been the only Ballyhoo Hours in radio's history. Others have been the inaugural hours of Palmolive, Wrigley and General Motors. Of any Ballyhoo Hour this is true: the sponsor's interest in the program is decidedly secondary to his interest in the printed stuff it gives him a chance to cook up and perchance, to have published. In other words the program is no end in itself but merely the excuse for deluging editor's desks with mimeographed mouthings.

In some ways it is idle for us to rail at the Ballyhoo Hour. It is both big business and good business. If it appears to exploit the sucker strain in the Americano the answer is that he likes to have it exploited. But as a gent whose waking hours are supposed to be concerned with the vital matter of seeing radio programs improved it is our bounden duty to eye such stuff aghast.

WE DO SOME EYEING AGHAST

OUR objection to the Ballyhoo Hour is precisely, that, while it doubtless does much good for the advertiser, it does nary a bit of good for radio. Furthermore it pains our frugal soul to see so much mazuma spent in such a wasteful way. Wasteful, as far as radio is concerned, because after one of these hours is over nothing remains, except perhaps an unpleasant taste. Nothing has been contributed to the "art" of broadcasting, no new precedent has been established upon which bigger and better developments may be built. Suppose some of the fifty or so thousand dollars that is commonly planked down for one of these programs were used for the employment of talented persons to create something new—such as the Sound Drama we suggested last month—that would be a real step.

But such arguments can carry no weight. It is too much to ask the advertiser to worry about the future of the radio art. We shall have to search another point of attack. Here's one: the novelty of these Big Splurge, Ballyhoo programs can't last forever. Since public interest in them is at bottom simply curiosity concerning the amount of money spent and the magnitude of the names employed, each succeeding big splurge is going to have to outdo its predecessor in order to pique the jaded curiosity of that public. Eventually it will be necessary to bill the crowned heads of Europe and transmit the stuff over jewelled platinum wires costing $9.85 an inch in order to get a rise out of the radio editors. So the Ballyhoo Program will very soon exterminate itself.

However, there is still another reason why the commercial broadcasters themselves ought to take steps to eliminate the ballyhoo program and that is that it doesn't serve to increase radio's prestige very much. The Big Splurge program attracts what the storekeeper knows as a Bargain Day Crowd. The merchant, on the day of a big sale, lures a lot of strangers into his store who have never crossed its threshold before. Most of them never will again; but a few of them may observe that his everyday merchandise is of good quality and may become habitual customers.

The Big Splurge program sucks in perhaps a couple million listeners who ordinarily disdain radio, refuse to purchase receivers and are only submitting to the pleas of friends to "come over and play a hand of bridge and listen to Such and Such." This is a swell chance to corral these prospective customers and make 'em come back for more. But the Pomp and Circumstance Program is prone to have one or other of the two following effects: *A*. The program turns out to be merely ordinary as entertainment, thus confirming the transient listener's opinion that radio is a moron's pastime or; *B*. Great musical artists are lavished with such profusion (as in some Victor Hours) that his follow-up essay at listening is dimmed to nothingness by contrast.

A Thursday Evening on the Blue Network

PERHAPS our eternal weeping in these columns over the fact that radio so seldom attains great art, and so frequently succeeds in being bad art, conveys the impression that we never get any enjoyment out of it at all. Not so. For instance last night, a Thursday evening in March:

Arming ourself against the ordeal with an entertaining novel, we plugged-in KYW, the local vendor of the Blue Network's wares, at 7:00 o'clock, Central Time. Well we didn't get in any reading during the first half hour. O. Henry's story, "The Clarion Call," was being presented in the "Re-Told Tales" series. Our listening was mostly a matter of conscientiousness for the first ten minutes, but after that the thing carried itself along for the remainder of the half hour and stacked up as one of the best radio plays we have heard. A two-character play, making use of a conventionally far-fetched O Henry plot it was "put across" by the expectionally fine voice acting of the villain. Sorry we don't remember his name; the good job of script preparation was done by one Henry Fisk Carlton and the production was directed by a Gerald Stopp.

At 7:30 when the Ampico Hour came on we commenced to look for our place in our book—for we have heard some rather dismal Ampico Hours. But unfortunately for novel reading the program opened with some of Smetana's music for "The Bartered Bride" which we like too much to miss. Then Marguerite Volavy, playing the piano both in solo and in concerto, kept our willing attention for the rest of the program.

We got in a little reading during the Maxwell House concert, but not much. This program is always craftily arranged and expertly presented. The "Old Colonel March" and the "Indian Love Lyrics" we could have got along very nicely without, but Richard Crooks called for sitting up and taking notice when he sang the "Prize Song" and the Siciliana from "Cavalleria." This grand singer—deservedly popular—even put beauty in the banal "Little Bit of Heaven." The orchestra kindly included a grand waltz from Komzak's "Bad'n Mad'l'n."

The Continental's program followed at 9:00 o'clock. This hour, too, is an ever reliable one, made up, as you know, of opera selections and not exclusively of the hackneyed ones. However, as two hours of attentive listening is enough for anybody to put in consecutively, we at this point took up our book and enjoyed the perfectly swell radio voices of Astrid Fjelde, Frederic Baer, et cie., as a rather vague background.

AT STATION WGR, BUFFALO

Nancy Cushman, daughter of Howard B. Cushman, director of the station, confiding to the world that she is two years old. "Microphone fright" does not seem to bother her

THE WBAL ENSEMBLE

This group is heard every Friday night from WBAL Baltimore. The group includes (left to right): Michael Weiner, violinist-conductor; Leroy Evans, pianist and Samuel Maurice Stern 'cellist. Michael Weiner is the orchestral supervisor. WBAL is one of the few stations that takes its music seriously

The Month's New Phonograph Records

SO MANY good words must be said for this month's supply of records that we feel we ought to offer a word of explanation at the start. Readers grow suspicious when any reviewer waxes consistently eulogistic. They picture all critics as mean creatures, shriveled in body and soul, who starve themselves on a diet of vinegar and sour grapes that they may the better enjoy the flaws which they pick, gloating over the bones of their victims. It fills us with joy to find a collection of records so good that we can honestly be lavish with praise. Such is the present collection.

Good and Popular

In the Sing Song Sycamore Tree and *Four Walls* played by the Ipana Troubadours directed, of course, by S. C. Lanin (Columbia). What is so rare as a really good tune? Two of them, of course. And here they are! Superbly played by the Troubadours and expertly sung by Scrappy Lambert.

The Whip and *We'll Have a New Home in the Morning* played by Nat Shilkret and the Victor Orchestra (Victor). Lyrics that are different, harmony that's grand, and an orchestra that's infectious.

Can't Help Lovin' Dat Man and *Make-Believe* played by Ben Bernie and His Hotel Roosevelt Orchestra (Brunswick). Smooth—in the best Bernie tradition, and with Vaughn De Leath and Scrappy Lambert doing neat vocalizing.

Say So! and *Oh Gee!—Oh Joy!* played by Ben Selvin and His Orchestra (Columbia). Yes, and we'll add a few more exclamation marks just for good measure!!!!

Mary Ann and *If I Can't Have You* played by Hal Kemp and His Orchesta formerly of the University of North Carolina. (Brunswick). Where they got their M. A. (musical acrobat) degrees, no doubt. No? Well, they got very proficient *some*where.

Call of Broadway and *Without You Sweetheart* played by Vincent Lopez and His Casa Lopez Orchestra (Brunswick). Mediocre music made more than a little danceable by a swell orchestra.

Sensation Stomp and *Whiteman Stomp* played by Paul Whiteman and His Orchestra (Victor). Whiteman conducts a class in orchestral gymnastics. Proving what?

Who Gives You All Your Kisses played by the Troubadours (Victor). As usual you can safely put your money on the Troubadours. They will even carry the weak sister on the other side. *What Are We Waiting For* played by Edwin J. McEnelly's Orchestra.

Tin Pan Parade played by the Troubadours (Victor) is another prize winner; *Chloe*, on the reverse, by the All Star Orchestra is just an also-ran.

Somebody Lied About Me and *Chloe* played by the Colonial Club Orchestra (Brunswick). Something old, nothing new, something borrowed, something blue.

Ol' Man River and *Can't Help Lovin' Dat Man* played by Don Voorhees and His Orchestra (Columbia). Two good numbers from the popular Ziegfeld musical comedy, "Show Boat."

My Ohio Home and *Here Comes the Showboat* played by Jean Goldkette and His Orchestra. (Victor). The second number is novel—and excellent.

Rose Room and *Golden Gate* by Herb Wiedoeft and His Orchestra (Brunswick). Musical publicity for the Land of Sunshine.

For My Baby and *The Man I Love* by Leo Reisman and His Orchestra and Fred Rich and His Hotel Astor Orchestra, respectively (Columbia). F. f. f. or fine for foxtrotting.

Tin Pan Parade and *I Told Them All About You* sung by Ford and Glenn (Columbia). Easily the best of the recent vocal records.

Sweetheart of Sigma Chi and *Charmaine* sung by Allen McQuhae (Brunswick). A better tenor voice than you usually hear warbling these grand old favorites!

In an Oriental Garden and *Roses for Remembrance* played by the Anglo-Persians under the direction of Louis Katzman (Brunswick). Mr. Katzman is the best musical gardener we know.

Lolita and *Yesterday* played by the A. and P. Gypsies under the direction of Harry Horlick (Brunswick). Very nice indeed.

More or Less Classic

Lucia—Sextette (Donizetti) and *Rigoletto—Quartet* (Verdi). (A) sung by Galli-Curci, Homer, Gigli, De Luca, Pinza, Bada; (B) sung by Galli-Curci, Homer, Gigli, De Luca (Victor). What's good enough for Gatti-Casazza is good enough for us.

Song of the Flea (Moussorgsky) and *Barbiere Di Siviglia—La Calunnia* (Rossini). Sung by Feodor Chaliapin (Victor). The name of this abysmal basso is sufficient guarantee of satisfaction on any record. This in particular is delightful.

Meistersinger-Kirchenchor (Wagner) and *Meistersinger-Wach' auf! Es Nahet Gen Den Tag* (Wagner). Sung by the State Opera Chorus of Berlin, with Orchestra, conducted by Leo Blech (Victor). A very effective imported recording of this beautiful choral music from Wagner's merry opera.

Pagliacci-Son Qua! and *Pagliacci-Andiam!* (Leoncavallo). Sung by the Metropolitan Opera Chorus, with Metropolitan Opera House Orchestra, conducted by Giulio Setti (Victor). More choral music that is worth several times the price of admission.

The Masked Ball—Is It Thou? (Verdi) and *Pagliacci—Prologue* (Leoncavallo) Sung by Heinrich Schlussnus (Brunswick). A competent baritone presents these two operatic selections.

Andante Cantabile (Tschaikowsky) and *Canzonetta* (Tschaikowsky). Played by Albert Spalding (Brunswick). Creating one paramount impression: that of charming grace.

Chanson Arabe (Rimsky-Korsakoff—Kreisler) and *Le Deluge* (Saint-Saens). Played by Toscha Seidel (Columbia). Mr. Seidel is assisted in the first selection by Max Rabinovitch at the piano, and in the second by Emanuel Bay—because it is the custom and not because this talented violinist needs assistance.

Ave Maria (Carnevali) and *Stabat Mater* (Pergolesi). Sung by Giuseppe Danise (Brunswick). A rich baritone voice lending itself very successfully to ecclesiastical music. The accompaniment of chimes in the *Ave Maria* is particularly nice.

Traviata—Prelude (Verdi) and *Sylvia Ballet—Cortege de Bacchus* (Delibes). Played by the Victor Symphony Orchestra directed by Rosario Bourdon (Victor). No home is complete without these familiar but none-the-less lovely selections.

Poet and Peasant Overture, Parts 1 and 2 (von Suppé). Played by the Brunswick Concert Orchestra (Brunswick). Part 1 is the dreamy poet; part 2: the rollicking peasant . . . but you know it; it has appeared on every "pop" concert program for years.

Emperor Waltz and *Wine, Woman and Song Waltz* (Strauss). By Jacques Jacobs' Ensemble (Columbia). Here are the waltzes of yesteryear!

Jolly Fellows Waltz (Wollstedt) and *The Skaters* (Waldteufel). Played by the Brunswick Concert Orchestra under the direction of Louis Katzman (Brunswick). Sweet memories of the old skating rink and the creaking calliope! The tunes are the same, that's all!

Recent Album Record Sets

WAGNER BAYREUTH FESTIVAL RECORDINGS (Columbia). In one album, Masterworks Set No. 79) the Columbia Phonograph Company offer the following excerpts from four Wagnerian operas: (1) *Parsifal: Transformation Scene*, Act 1; *Grail Scene*, Act 1; *Flower Maidens' Scene*, Act. 2; *Prelude*, Act 3; and *Good Friday Music*, Act 3; (2) *Rheingold:* Entry of the Gods into Valhalla; (3) *Die Walkure: Ride of the Valkyries:* (4) *Siegfried: Forest Murmurs*, Act 2; *Prelude*, Act 3; *Fire Music*. The orchestra is that of the Bayreuth Festival, over which three famous conductors share the honors of wielding the baton. They are Dr. Karl Muck, one time director of the Boston Symphony Orchestra, Siegfried Wagner, and Franz von Hoesslin. The recordings were made in Bayreuth during actual performances of the operas in the summer of 1927 and have been approved by Siegfried Wagner.

We will not go into a detailed description of the records. You either know and love the music or you don't. If you do, you will want the album anyway. If you don't, you should get the album and learn to know the music.

The set contains eleven double-faced records and costs $16.50.

Symphony No. 4, D Minor, (Op. 120) by Robert Schumann. Played by the New Symphonic Orchestra, Berlin, under the direction of Hans Pfitzner. Complete on three and a half double-faced records (Brunswick).

Schumann conceived the Fourth Symphony as a whole rather than as four distinct movements. The same thematic material runs through the entire work. The symphony is very colorful, very warm and full of lovely melodic phrases. The fourth movement is particularly beautiful.

Concerto for Organ and Orchestra, F Major, (Op. 4, No. 4) by George Frederic Handel. Played by Walter Fischer accompanied by orchestra. Complete on two double-faced records. *Concerto for Organ and Orchestra, F Major (Op. 177)* by Joseph Rheinberger. Played by Walter Fischer accompanied by orchestra. Complete on three double-faced records. (Brunswick).

The Brunswick-Balke-Collender Company would have acted more wisely had they separated these two concertos rather than offered them together in one album. The Rheinberger Concerto, which is in spots uninteresting to the point of dullness suffers sadly by contrast with the exquisite Handel composition. Both concertos are beautifully played by the famous organist of the Berlin Cathedral.

Death and Transfiguration (Op. 24) by Richard Strauss, played by the State Opera Orchestra under the direction of the composer. Complete on three double-faced records (Brunswick).

This tone poem dealing with the struggle between life and death is one of the most powerfully dramatic of modern orchestral compositions.

"Radio Broadcast's" Directory of Vacuum Tubes

THE table below is as complete as is possible to make it and should be a constantly useful reference for all radio workers. The data on some Western Electric tubes are included because some of our readers live in Canada and in other countries where tubes of this manufacture are available. We have followed the RCA-Cunningham tube terminology; other manufacturers make types of tube similar in each class, although each manufacturer has his own terminology. The reader who desires to use a CeCo tube for example, need only ask his dealer or the manufacturer for a CeCo of the 201-A type, etc. The same follows naturally for any of the vacuum tubes in the classifications below made by Arcturus, Sovereign, Sylvania, Marathon, Gold Seal, Sonatron, Kellogg, Magnetron, Speed, and others.

AVERAGE CHARACTERISTICS OF RADIO VACUUM TUBES

GENERAL							DETECTION				AMPLIFICATION						
MODEL	USE	CIRCUIT REQUIREMENTS	INTER-ELECTRODE CAPACITIES IN MMFD. FILAMENT COLD	"A" SUPPLY	FILAMENT TERMINAL VOLTAGE	FILAMENT CURRENT (AMPERES)	DETECTOR GRID RETURN LEAD TO	GRID LEAK MEGOHMS	DETECTOR "B" BATTERY VOLTAGE	DETECTOR PLATE CURR'T (MILLIAMPERES)	AMPLIFIER "B" BATTERY VOLTAGE	AMPLIFIER "C" BATTERY VOLTAGE	AMPLIFIER PLATE CURRENT (MILLIAMPERES)	A.C. PLATE RESISTANCE (OHMS)	MUTUAL CONDUCTANCE MICROMHOS	VOLTAGE AMPLIF'TON FACTOR	MAXIMUM UNDISTORTED OUTPUT (MILLIWATTS)
Detectors and Amplifiers																	
C-11 WD-11					Same as below, except for base, which is old UV type												
CX-12 WX-12	Detector or Amplifier	Transformer Coupling	G-F 6; G-P 5.5; P-F 7.5	Dry Cell 1½ V Storage 2 V	1.1	.25	+F	3 to 5	22½ to 45	1.5	90 135	4½ 10½	2.5 3.5	15,500 15,000	425 440	6.6 6.6	7 35
CX-112 A UX-112 A	Detector or ↓ Amplifier	Transformer Coupling	G-F 9; G-P 11; P-F 7.5	Storage 6 V	5.0	.25	+F	3 to 5	45	1.5	90 135	4½ 9	5.5 7	5,300 5,000	1,500 1,600	8 8	30 120
C-299 UV-199					Same as below, except for base, which is old UV type												
CX-299 UX-199	Detector or Amplifier	Transformer Coupling	G-F 3.6; G-P 3.5; P-F 4.5	Dry Cell 4½ V. Storage 4 V.	3.0 3.3	.060 .063	+F	2 to 9	45	1	90	4½	2.5	15,500	425	6.6	7
CX-300 A UX-200 A	Detector	Transf. or Resis. Coupling	G-F 3.4; G-P 8.8; P-F 1.5	Storage 6 V	5.0	.25	-F	2 to 3	45	1.5	Following UX-200 A characteristics apply only for Detector connection			30,000	666	20	—
CX-301 A UX-201 A	Detector or Amplifier	Transformer Coupling	G-F 5.8; G-P 10.1; P-F 6.1	Storage 6 V	5.0	.25	+F	2 to 9	45	1.5	90 135	4½ 9	2.5 3	11,000 10,000	725 800	8 8	15 55
CX-322 UX-222	Radio Freq. ↓ Amplifier	Special Shielding	G-P 0.025	Dry Cell 4½ V. Storage 4-6 V.	3.3	.132	—	—	—	—	135	1½*	1.5	850,000	350	300 M	—
CX-322 UX-222	Audio Freq. ↑ Amplifier	Resistance Coupling	—	Dry Cell 4½ V. Storage 4-6 V.	3.3	.132	—	—	—	—	180 §	1½ □	.3	160,000	400	60	—
UX-226 CX-326	Amplifier A.C. Filament Type	Transformer Coupling	G-F 3.65; G-P 8.2; P-F 2.1	Transformer 1.5 V.	1.5	1.05	—	—	—	—	90 135 180	6 9 13½	3.5 6 7.5	9,400 7,400 7,000	875 1,100 1,170	8.2 8.2 8.2	20 70 160
C-327 UY-227	Detector A.C. Heater Type	Transformer Coupling	G-F 3.6; G-P 3.7; P-F 2.75	Transformer 2.5 V.	2.5 H	1.75	K	2-9 ¼-1	45 90	2 7	Following UY-227 characteristics apply only for Detector connection			10,000 8,000	800 1,000	8 8	—
CX-340 UX-240	Detector or Amplifier	Resistance Coupling	G-F 3.4; G-P 8.8; P-F 1.5	Storage 6 V	5.0	.25	+F	2 to 5	135 § 180 §	0.3 0.4	135 § 180 §	1½ 3	.2 .2	150,000 150,000	200 200	30 30	—
Power Amplifiers																	
CX-112 A UX-112 A	↑ Power Amplifier	No L.S.C. Required	G-F 9; G-P 11; P-F 7.5	Storage 6 V. Transformer 5 V.	5.0	.25	—	—	—	—	135 157½	9 10½	7 9.5	5,000 4,700	1,600 1,700	8 8	120 195
CX-220 UX-120	Power Amplifier	No L.S.C. Required	G-F 4.5; G-P 5.4; P-F 4.4	Dry Cell 4½ V. Storage 4 V.	3.0 3.3	.125 .132	—	—	—	—	135	22½	6.5	6,300	525	3.3	110
CX-371 A UX-171 A	Power Amplifier	L.S.C. except at 90 V.	G-F 6.8; G-P 9.5; P-F 6.5	Storage 6 V. Transformer 5 V.	5.0	.25	—	—	—	—	90 135 180	16½ 27 40½	10 16 20	2,500 2,200 2,000	1,200 1,360 1,500	3.0 3.0 3.0	130 330 700
CX-310 UX-210	Power Amplifier	L.S.C.	G-F 7; G-P 8; P-F 7	Transformer 7.5 V.	7.5	1.25	—	—	—	—	250 300 350 400 425	18 22½ 27 31½ 35	10 13 16 18 18	6,000 5,600 5,150 5,000 5,000	1,330 1,450 1,550 1,600 1,600	8 8 8 8 8	340 600 925 1,325 1,540
CX-350 UX-250	Power Amplifier	L.S.C.	G-P 8.7	Transformer 7.5 V.	7.5	1.25	—	—	—	—	250 300 350 400 450	45 54 63 70 84	28 35 45 55 55	2,100 2,000 1,900 1,800 1,800	1,800 1,900 2,000 2,100 2,100	3.8 3.8 3.8 3.8 3.8	900 1,500 2,350 3,250 4,650
AVERAGE CHARACTERISTICS OF WESTERN ELECTRIC TUBES																	
"N" 215-A	Detector or Amplifier	Transformer Coupling	G-F 4.4; G-P 6; P-F 3.8	—	1.0	0.25	+F	2-9	45	1.0	67	6.0	1.0	20,000	300	6	8
"V" 102 D	Amplifier	Resis. or Impedance Coupling	—	—	2.0	0.97	—	—	—	—	130	1.5	0.75	60,000	500	30	4.2
"L" 216 A	Amplifier	Transformer Coupling	—	—	5-6	1.0	—	—	—	—	130	9.0	8.0	6,000	980	5.9	60
"O" 104 D	Power Amplifier	Transformer or Imped. Coupling	G-F 8.2; G-P 5.46; P-F 8.0	—	4-5	1.0	—	—	—	—	130	22.5	20.0	2,200	1,100	2.4	145
"E" 205 D	Power Amplifier	Transformer or Imped. Coupling	—	—	4.5	1.6	—	—	—	—	350	22.5	33	3,500	2,000	7	890

SPECIAL PURPOSE TUBES

MODEL	USE	CIRCUIT REQUIREMENTS	BASE	MAXIMUM OVERALL HEIGHT	MAXIMUM OVERALL DIAMETER	PURPOSE	CHARACTERISTICS	
CX-380 UX-280	Full-Wave Rectifier	Full-Wave Circuit	Large Standard UX Base	$5\frac{5}{8}''$	$2\frac{3}{16}''$	Rectification in Eliminators	Filament Terminal Voltage...5 Volts Filament Current............2 Amperes A.C. Plate Voltage...........300 Volts (Max. per Plate) R.M.S.	Max. D.C. Output Current (both Plates)............125 Milliamperes D.C. Output Voltage at Max. Current as applied to filter of typical rectifier circuit............260 Volts
CX-381 UX-281	Half-Wave Rectifier	Half or Full Wave Circuit	Large Standard UX Base	$6\frac{1}{4}''$	$2\frac{7}{16}''$	Rectification in Eliminators	Filament Terminal Voltage...7.5 Volts Filament Current.......1.25 Amperes A.C. Plate Voltage..........750 Volts (Maximum) R.M.S.	Recommended — Maximum A.C. Plate Voltage............650...750 Volts D.C. Output Current............65...110 Milliamperes D.C. Output Voltage as applied to filter of typical rectifier circuit...620...620 Volts
CX-374 UX-874	Voltage Regulator	Series Resistance	Large Standard UX Base	$5\frac{5}{8}''$	$2\frac{3}{16}''$	Constant Voltage Device	Designed to keep output voltage of B Power Units constant when different values of "B" current are supplied	Operating Voltage........90 Volts D.C. Starting Voltage..........125 Volts D.C. Operating Current.....10-50 Milliamperes
C-376 UX-876	Current Regulator (Ballast Tube)	Transformer Primary of 65 Volts for use on 115 Volt Line	Standard Mogul Type Screw Base	8"	$2\frac{1}{16}''$	Constant Current Device	Designed to insure constant input to power operated radio receivers despite fluctuations in line voltage	Operating Current.........1.7 Amperes Mean Voltage Drop........50 Volts Permissible Variation.....±10 Volts
C-386 UX-886	Current Regulator (Ballast Tube)	Transformer Primary of 65 Volts for use on 115 Volt Line	Standard Mogul Type Screw Base	8"	$2\frac{1}{16}''$	Constant Current Device	Designed to insure constant input to power operated radio receivers despite fluctuations in line voltage	Operating Current.......2.05 Amperes Mean Voltage Drop........50 Volts Permissible Variation......±10 Volts
C-377	Protective Tube	—	Double △ Contact Bayonet Auto. Type	$1\frac{7}{16}''$	$2\frac{1}{2}''$	Current Limiting Device	Used in "B" Battery circuits to prevent excessive current resulting from short-circuit which might damage tubes or wiring	Voltage Drop Across — Half Filament: 2.5, Entire Filament: 5, At 20 Milliamperes D.C. Half Filament: 45, Entire Filament: 90, At 90 Milliamperes D.C.

‡ (↓) Note other use of this Radiotron above (below)
* Inner Grid −1½ Volts; Outer Grid +45 Volts, 0.15 Milliamperes
□ Outer Grid −1½ Volts; Inner Grid +22½ Volts, 6 Milliamperes
§ Applied thru plate coupling resistance of 250,000 Ohms
△ Connection to shell of base for third terminal which is the lead to mid-point of filament

Note: All grid voltages are given with respect to cathode or negative filament terminal

Maximum values not to be exceeded

Except for half ampere filament, UX-112 and UX-171 characteristics are identical respectively to UX-112-A and UX-171-A.
K.....Cathode
H.....Heater Voltage
L.S.C...Loud Speaker Coupling, consisting of either Choke Coil and By-Pass Condenser or Output Transformer of 1:1 or step down ratio, recommended wherever plate current (D.C.) exceeds 10 milliamperes.
M.....With a screen-grid tube, on account of circuit limitations, the actual voltage amplification obtainable does not bear as high a relation to the voltage amplification factor as in the case of three element tubes.

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on this page. Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. RADIALL COMPANY.
2. HARD RUBBER PANELS—Characteristics and properties of hard rubber as used in radio, with suggestions on how to "work" it. B. F. GOODRICH RUBBER COMPANY.
3. TRANSFORMERS—A booklet giving data on input and output transformers. PACENT ELECTRIC COMPANY.
5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.
9. VOLUME CONTROL—A leaflet showing circuits for distortionless control of volume. CENTRAL RADIO LABORATORIES.
10. VARIABLE RESISTANCE—As used in various circuits. CENTRAL RADIO LABORATORIES.
12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.
15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.
15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.
16. VARIABLE CONDENSERS—A description of the functions and characteristics of variable condensers with curves and specifications for their application to complete receivers. ALLEN D. CARDWELL MANUFACTURING COMPANY.
17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION.
21. HIGH-FREQUENCY DRIVER AND SHORT-WAVE WAVEMETER—Constructional data and application. BURGESS BATTERY COMPANY.
46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.
47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.
48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.
49. BYPASS CONDENSERS—A description of the manufacture of bypass and filter condensers. LESLIE F. MUTER COMPANY.
50. AUDIO MANUAL—Fifty questions which are often asked regarding audio amplification, and their answers. AMERTRAN SALES COMPANY, INCORPORATED.
51. SHORT-WAVE RECEIVER—Constructional data on a receiver which, by the substitution of various coils, may be made to tune from a frequency of 16,660 kc. (18 meters) to 1999 kc. (150 meters). SILVER-MARSHALL, INCORPORATED.
52. AUDIO QUALITY—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. SILVER-MARSHALL, INCORPORATEN.
56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.
57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.
59. RESISTANCE COUPLING—A booklet giving some general information on the subject of radio and the application of resistors to a circuit. DAVEN RADIO CORPORATION.
63. FIVE-TUBE RECEIVER—Constructional data on building a receiver. AERO PRODUCTS, INCORPORATED.
70. IMPROVING THE AUDIO AMPLIFIER—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. AMERICAN TRANSFORMER COMPANY.
72. PLATE SUPPLY SYSTEM—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. AMERTRAN SALES COMPANY.
81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.
82. SIX-TUBE RECEIVER—A booklet containing photographs, instructions, and diagrams for building a six-tube shielded receiver. SILVER-MARSHALL, INCORPORATED.
83. SOCKET POWER DEVICE—A list of parts, diagrams, and templates for the construction and assembly of socket power devices. JEFFERSON ELECTRIC MANUFACTURING COMPANY.
84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.
85. FILTER—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. THE ABOX COMPANY.
86. SHORT-WAVE RECEIVER—A booklet containing data on a short-wave receiver as constructed for experimental purposes. THE ALLEN D. CARDWELL MANUFACTURING CORPORATION.
88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.
89. SHORT-WAVE TRANSMITTER—Data and blue prints are given on the construction of a short-wave transmitter, together with operating instructions, methods of keying, and other pertinent data. RADIO ENGINEERING LABORATORIES.
90. IMPEDANCE AMPLIFICATION—The theory and practice of a special type of dual-impedance audio amplification are given. ALDEN MANUFACTURING COMPANY.
93. B-SOCKET POWER—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. NATIONAL COMPANY, INCORPORATED.
94. POWER AMPLIFIER—Constructional data and wiring diagrams of a power amplifier combined with a B-supply unit are given. NATIONAL COMPANY, INCORPORATED.
101. USING CHOKES—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. SAMSON ELECTRIC COMPANY.
22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.
23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.
26. DRY CELLS FOR TRANSMITTERS—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. BURGESS BATTERY COMPANY.
27. DRY-CELL BATTERY CAPACITIES FOR RADIO TRANSMITTERS—Characteristic curves and data on discharge tests. BURGESS BATTERY COMPANY.
28. B BATTERY LIFE—Battery life curves with general curves on tube characteristics. BURGESS BATTERY COMPANY.
30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.
32. METERS FOR RADIO—A catalogue of meters used in radio, with diagrams. BURTON-ROGERS COMPANY.
33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.
35. STORAGE BATTERY OPERATION—An illustrated booklet on the care and operation of the storage battery. GENERAL LEAD BATTERIES COMPANY.
36. CHARGING A AND B BATTERIES—Various ways of connecting up batteries for charging purposes. WESTINGHOUSE UNION BATTERY COMPANY.
37. WHY RADIO IS BETTER WITH BATTERY POWER—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.
53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.
69. VACUUM TUBES—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. RADIO CORPORATION OF AMERICA.
87. TUBB TESTER—A complete description of how to build and how to operate a tube tester. BURTON-ROGERS COMPANY.
92. RESISTORS FOR A. C. OPERATED RECEIVERS—A booklet giving circuit suggestions for building a. c. operated receivers, together with a diagram of the circuit used with the new 400-milliampere rectifier tube. CARTER RADIO COMPANY.
102. RADIO POWER BULLETINS—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the BH or B rectifier tubes. RAYTHEON MANUFACTURING COMPANY.
103. A. C. TUBES—The design and operating characteristics of a new a. c. tube. Five circuit diagrams show how to convert well-known circuits. SOVEREIGN ELECTRIC & MANUFACTURING COMPANY.

In sending the coupon below, make sure that your name and address are included and are plainly written.

USE THIS BOOKLET COUPON

RADIO BROADCAST SERVICE DEPARTMENT
RADIO BROADCAST, *Garden City, N. Y.*
Please send me (at no expense) the following booklets indicated by numbers in the published list above:

....

....

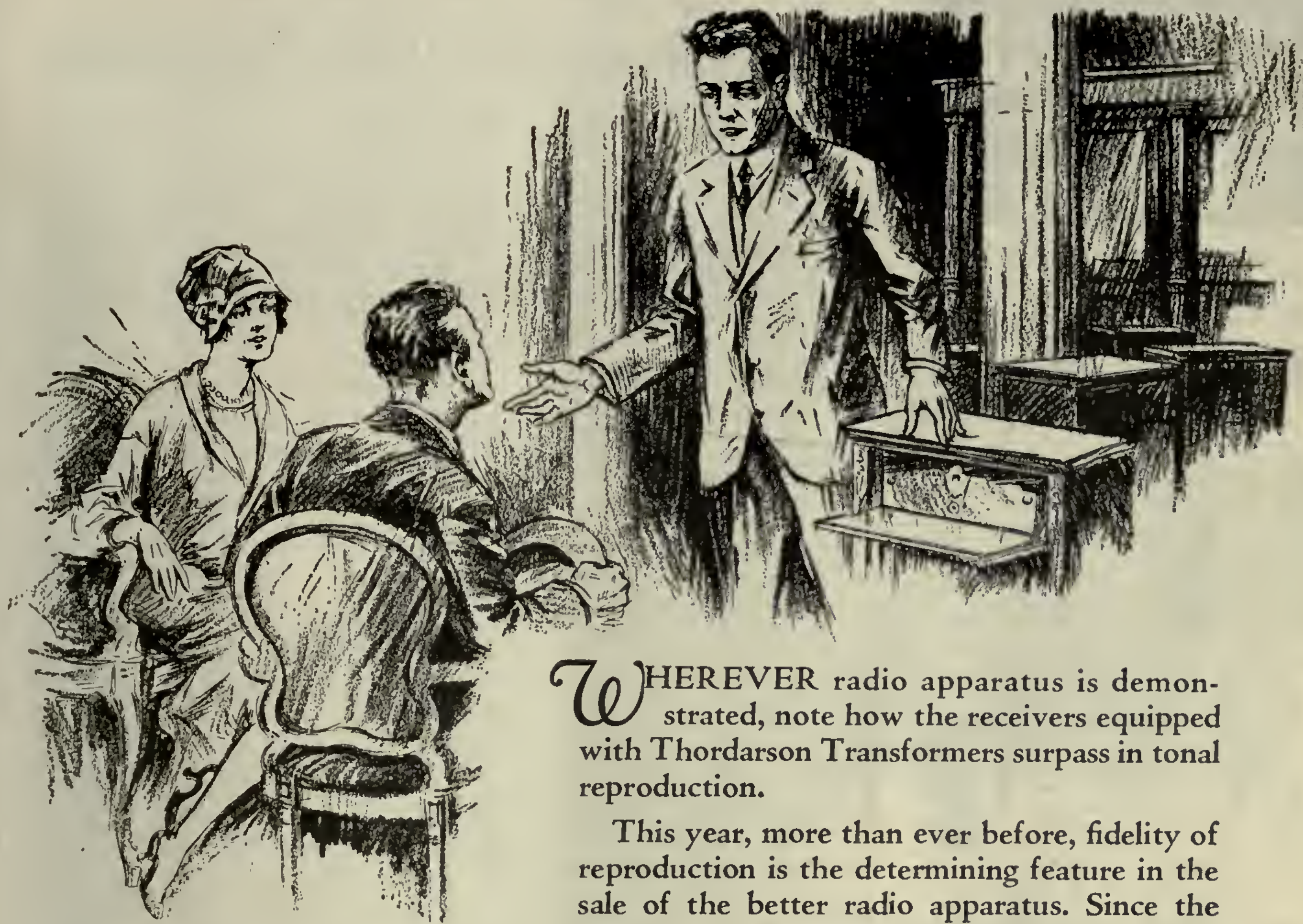
Name..

Address..
(Number) *(Street)*

....
(City) *(State)*

ORDER BY NUMBER ONLY
This coupon must accompany every request. RB 6-28

41. BABY RADIO TRANSMITTER OF 9XH-9EK—Description and circuit diagrams of dry-cell operated transmitter. BURGESS BATTERY COMPANY.
42. ARCTIC RADIO EQUIPMENT—Description and circuit details of short-wave receiver and transmitter used in Arctic exploration. BURGESS BATTERY COMPANY.
58. HOW TO SELECT A RECEIVER—A commonsense booklet describing what a radio set is, and what you should expect from it, in language that any one can understand. DAY-FAN ELECTRIC COMPANY.
67. WEATHER FOR RADIO—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. TAYLOR INSTRUMENT COMPANIES.
73. RADIO SIMPLIFIED—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. CROSLEY RADIO CORPORATION.
76. RADIO INSTRUMENTS—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. JEWELL ELECTRICAL INSTRUMENT COMPANY.
78. ELECTRICAL TROUBLES—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. BURTON ROGERS COMPANY.
95. RESISTANCE DATA—Successive bulletins regarding the use of resistors in various parts of the radio circuit. INTERNATIONAL RESISTANCE COMPANY.
96. VACUUM TUBE TESTING—A booklet giving pertinent data on how to test vacuum tubes with special reference to a tube testing unit. JEWELL ELECTRICAL INSTRUMENT COMPANY.
98. COPPER SHIELDING—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. THE COPPER AND BRASS RESEARCH ASSOCIATION.
99. RADIO CONVENIENCE OUTLETS—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set. YAXLEY MANUFACTURING COMPANY.
105. COILS—Excellent data on a radio-frequency coil with constructional information on six broadcast receivers, two short-wave receivers, and several transmitting circuits. AERO PRODUCTS COMPANY.
106. AUDIO TRANSFORMER—Data on a high-quality audio transformer with circuits for use. Also useful data on detector and amplifier tubes. SANGAMO ELECTRIC COMPANY.
108. VACUUM TUBES—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. ARCTURUS RADIO COMPANY.
109. RECEIVER CONSTRUCTION—Constructional data on a six-tube receiver using restricted field coils. BODINE ELECTRIC COMPANY.
110. RECEIVER CONSTRUCTION—Circuit diagram and constructional information for building a five-tube set using restricted field coils. BODINE ELECTRIC COMPANY.
111. STORAGE BATTERY CARE—Booklet describing the care and operation of the storage battery in the home. MARKO STORAGE BATTERY COMPANY.
112. HEAVY-DUTY RESISTORS—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. WARD LEONARD ELECTRIC COMPANY.
113. CONE LOUD SPEAKERS—Technical and practical information on electro-dynamic and permanent magnet type cone loud speakers. THE MAGNAVOX COMPANY.
114. TUBE ADAPTERS—Concise information concerning simplified methods of including various power tuhes in existing receivers. ALDEN MANUFACTURING COMPANY.
115. WHAT SET SHALL I BUILD?—Descriptive matter, with illustrations, of fourteen popular receivers for the home constructor. HERBERT H. FROST, INCORPORATED.
104. OSCILLATION CONTROL WITH THE "PHASATROL"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. ELECTRAD, INCORPORATED.
116. USING A B POWER UNIT—A comprehensive booklet detailing the use of a B power unit. Tables of voltages—both B and C—are shown. There is a chapter on trouble-shooting. MODERN ELECTRIC MFG. CO.
117. BEST RESULTS FROM RADIO TUBES—The chapters are entitled: "Radio Tubes," "Power Tubes," "Super Detector Tubes," "A. C. Tubes," "Rectifier Tubes," and "Installation." GOLD SEAL ELECTRICAL CO.
118. RADIO INSTRUMENTS, CIRCULAR "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. WESTON ELECTRICAL INSTRUMENT CORPORATION.
120. THE RESEARCH WORKER—A monthly bulletin of interest to the home constructor. A typical feature article describes the construction of a special audio amplifier—AEROVOX WIRELESS CORPORATION.
121. FILTER CONDENSERS—Some practical points on the manufacture and use of filter condensers. The difference between inductive and non-inductive condensers. POLYMET MFG. CORP.
122. RADIO TUBES—Specifications and operating characteristics of vacuum tubes. Twenty-four pages. E. T. CUNNINGHAM, INC.
123. B SUPPLY DEVICES—Circuit diagrams, characteristics, and list of parts for nationally known power supply units. ELECTRAD, INC.
124. POWER AMPLIFIER AND B SUPPLY—A booklet giving several circuit arrangements and constructional information and a combined B supply and push-pull audio amplifier, the latter using 210 type tubes. THORDARSON ELECTRIC MFG. CO.
125. A. C. TUBE OPERATION—A small but complete booklet describing a method of filament supply for a.c. tubes. THORDARSON ELECTRIC MFG. CO.
126. MICROMETRIC RESISTANCE—How to use resistances for: Sensitivity control; oscillation control; volume control; regeneration control; tone control; detector plate voltage control; resistance and impedance coupling; loud speaker control, etc. AMERICAN MECHANICAL LABORATORIES.



WHEREVER radio apparatus is demonstrated, note how the receivers equipped with Thordarson Transformers surpass in tonal reproduction.

This year, more than ever before, fidelity of reproduction is the determining feature in the sale of the better radio apparatus. Since the musical characteristics of a radio instrument depend to such a great extent on a wise selection of the audio and power supply transformers, it is significant that so many leading manufacturers have turned to Thordarson as the logical transformer source.

Equally significant is the fact that not once since Thordarson transformers became available to radio manufacturers has any other transformer approached the manufacturer popularity of Thordarson.

These quality instruments are Thordarson equipped:

Zenith
Sparton
Howard
Philco
Willard
Pfanstiehl
Gilfillan
Kennedy
Magnavox
Neutrowound
Prest-O-Lite
Radiodyne
Mohawk
Buckingham
Murdock
Walbert
Ozarka
Argus
Audiola
Erla
and many others

THORDARSON
RADIO TRANSFORMERS
Supreme in musical performance

Thordarson transformers are universally available to custom set builders as well as manufacturers. Wherever radio parts are sold, there you will find a complete stock of Thordarson Audio and Power Supply apparatus. If you are building for real musical performance, insist on Thordarson Transformers.

THORDARSON ELECTRIC MANUFACTURING CO.
Transformer Specialists Since 1895
WORLD'S OLDEST AND LARGEST EXCLUSIVE TRANSFORMER MAKERS
Huron and Kingsbury Streets — Chicago, Ill. U.S.A. 3581

The *Radio Broadcast*

LABORATORY INFORMATION SHEETS

THE Radio Broadcast Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4" x 6" filing cards, or in a notebook. The cards should be arranged in numerical order. In July, 1927, an index to all Sheets appearing up to that time was printed. Last month we printed an index covering the sheets published from August, 1927, to May, 1928, inclusive.

All of the 1926 issues of Radio Broadcast are out of print. A complete set of Sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Orders for the next set following can also be sent. Some readers have asked what provision is made to rectify possible errors in these Sheets. In the unfortunate event that any serious errors do occur, a new Laboratory Sheet with the old number will appear.

—The Editor.

No. 193 Radio Broadcast Laboratory Information Sheet June, 1928

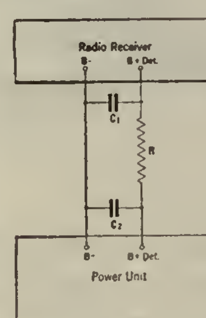
"Motorboating"

HOW IT CAN BE PREVENTED

MANY amplifiers at times show a tendency to "motorboat" due generally to interaction coupling between stages, due to common coupling in the plate-supply unit. This effect can generally be eliminated by using the circuit shown on this Laboratory Sheet. This circuit was suggested in a recent bulletin from the E. T. Cunningham Company.

The anti-motorboating circuit consists of a network of condensers and resistances connected between the power unit and the B-plus detector terminal on the radio receiver. The effect of this circuit apparently is to eliminate coupling effects at the low frequencies at which such effects are most troublesome. The circuit has been used with good results in the Laboratory, in connection with resistance-coupled amplifiers which generally show the strongest tendency to motorboat, but the circuit may be satisfactorily used with any type of amplifier.

It is not difficult to add this circuit to any existing receiver installation. To do this it is simply necessary to connect the resistance R in series with the lead connecting between the B-plus detector terminal on the receiver and the B-plus detector terminal on the power unit. One 2.0-mfd. condenser C_1 must then be connected between the B-plus terminal and the B-minus on the receiver and another condenser C_2 connected between the B-plus detector and minus B terminal on the power unit. It is preferable to locate the resistance at a point close to the receiver rather than near the power unit.



The value of the resistance depends to some extent upon the characteristics of the receiver and the power unit. With some amplifiers we have found a value of 10,000 ohms to be satisfactory, and with other amplifiers, a resistance of 50,000 to 100,000 ohms was required to prevent motorboating. A value of about 50,000 ohms seems to be satisfactory in most cases.

No. 194 Radio Broadcast Laboratory Information Sheet June, 1928

Push-Pull Amplifiers

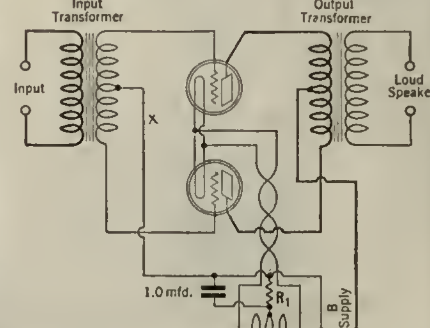
HOWLING

PUSH-PULL type amplifiers in many cases exhibit a tendency to howl at some audio frequency due to feedback through the interelectrode capacity of the tubes. When this occurs it is obviously impossible to obtain satisfactory operation from the amplifier. The howling in push-pull amplifiers can generally be readily prevented by connecting a choke coil or resistance at the point marked X in the circuit diagram. When constructing an amplifier of this type it is wise to include such a choke or resistance in the circuit; no by-pass condenser should be placed across the unit.

The inclusion of choke or resistance in this circuit will not affect the quality for this circuit does not have to carry any audio-frequency currents. In some instances it will be found necessary to prevent howling to include also a choke coil in the lead from the center tap of the output transformer and the B-plus terminal of the plate supply.

If a resistance is used in the grid circuit it should have a value of about 50,000 ohms. Since it does not have to carry any current, any ordinary grid leak type of resistance unit may be used. The chokes used may be any type with an inductance of about 10 henries or more. The primary of an old audio-frequency transformer might be used in the grid circuit but is not satisfactory for inclusion in the plate circuit between the center tap of the output transformer and the plate supply for when connected at this point, the choke must carry the plate current of the two tubes, which may be enough to burn out the windings of an ordinary audio transformer. Use at this point some device designed to carry 50 or 60 milliamperes. The circuit given on this sheet also shows the use of a resistance R_1 to supply C bias to the two tubes. Its value, depending upon the type of tubes used, is given below

Type of Tube	R_1
112-A	750 ohms
171-A	1000 ohms
210	1100 ohms



No. 195 RADIO BROADCAST Laboratory Information Sheet June, 1928

A Resistance-Coupled Amplifier With Screen-Grid Tubes

CONSTRUCTIONAL DATA

THE February, 1927, RADIO BROADCAST reported some experiments made in the Laboratory on the use of the screen-grid tube in audio-frequency and radio-frequency amplifiers, and in the article there appeared a circuit diagram of a resistance-coupled, audio-frequency amplifier using two screen-grid tubes. Many letters have been received requesting constructional data on this amplifier and we have therefore reprinted the circuit diagram on Laboratory Sheet No. 196 and the list of parts necessary to construct the amplifier appears at the end of this Sheet.

The publication of this circuit diagram and list of parts should not be taken to indicate unqualified endorsement of the amplifier for its high voltage gain of 2200 (the voltage gain of an average two-stage transformer coupled amplifier is 250) in some cases will prove more of a disadvantage rather than an advantage. The disadvantage of a high gain audio-frequency amplifier will become evident when an attempt is made to operate it from a B-power unit. When an ordinary amplifier is used with a plate-supply unit which provides hum-free operation no difficulty may ensue; but when this same supply is connected to a high-gain, screen-grid amplifier, the hum is greatly magnified and may be of entirely too high a value. If the screen-grid tubes are operated from batteries, however, this amplifier will give very satisfactory results.

To construct this amplifier the following parts are necessary:

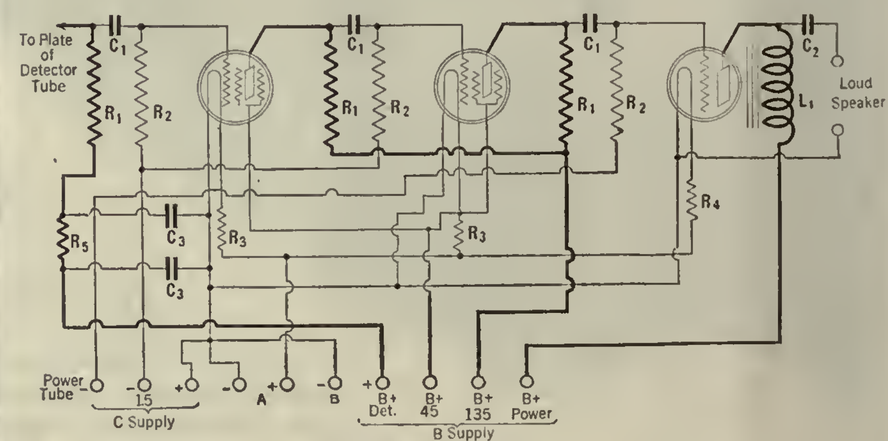
R_1, 0.25-Megohm Resistors
R_2, 2.0-Megohm Resistors
R_3, 20-Ohm Filament Resistors
R_4, 4-Ohm Resistor
R_5, 0.1-Megohm Resistor
C_1, 0.01-Mfd. Fixed Condensers
C_2, 4.0-Mfd. Fixed Condensers
C_3, 2.0-Mfd. Bypass Condensers
Three Sockets
Binding Posts

No special care is required in the construction of this amplifier although it is wise to arrange the layout so that the various grid and plate leads are short. The condensers C_3 and the resistor R_5 are incorporated in the circuit to prevent the amplifier from motorboating. This circuit will also help to keep the hum low if the device is operated from a B-power unit.

A frequency characteristic curve of this amplifier made in this Laboratory showed it to be flat from 100 to 10,000 cycles.

No. 196 RADIO BROADCAST Laboratory Information Sheet June, 1928

Circuit of a Resistance-Coupled Screen-Grid Amplifier



No. 197 RADIO BROADCAST Laboratory Information Sheet June, 1928

Amplification Constant

HOW IT MAY EASILY BE MEASURED

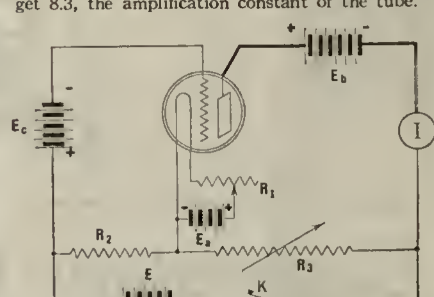
IT IS not difficult with simple apparatus to measure the amplification constant of any tube. The important apparatus required to make such a test are two accurate resistances, one variable, the other fixed, and a milliammeter capable of carrying the normal plate current of the tube under test. The circuit diagram to be followed in making this test is given here. The following parts are used in the circuit:

E_c—C-battery with a value correct for the tube under test. E_b—B-battery with a value correct for the tube under test. E_a—Source of filament voltage. E—45 volt B-battery. R_1—Filament rheostat. R_2—Accurate 10-ohm resistor. R_3—Accurate variable resistor, having a maxmum value of 300 or 400 ohms. I—Milliammeter having a maximum range of about 20 milliamperes. K—Key to open and close the circuit.

The important resistor in this circuit is R_1 which must be calibrated. A good potentiometer may be used, provided it is supplied with a dial so that the amount of resistance included in the circuit can be calculated. For example, if the potentiometer has a resistance of 400 ohms and the dial reads from 0 to 100 then each degree would include 4 ohms.

The test is conducted as follows. With K open, adjust E_c and E_b so that the tube is being operated under the correct conditions of grid and plate voltage. Note the plate current reading. Now depress K and note the change in the reading of the milliammeter. Adjust R_1 so that as the key is opened and closed no change takes place in the reading of the milliammeter. When resistor, R_1, has been adjusted so that the plate current remains constant, calculate the amount of resistance at R_1, included in the circuit. Divide this resistance by 10, the value of R_2, and the quotient will be the amplification constant of the tube.

EXAMPLE: A 201-A type tube is being tested and a balance is obtained when there are 83 ohms included in the circuit at R_1. Dividing 83 by 10 we get 8.3, the amplification constant of the tube.



Concentrated Effort!

IN specializing on and perfecting condensers and resistors which have stood up under every test made to determine their worth, the Aerovox Wireless Corp. has attained a goal made possible only by perfect co-ordination, co-operation, and concentration of every element in an organization devoted exclusively to the production of high quality condensers and resistors.

The Aerovox Research Worker is a free monthly publication that will keep you abreast of the latest developments in Radio. A post card will put you on the mailing list.

AEROVOX

78 WASHINGTON ST.
BROOKLYN, N. Y.

PARALLEL PLATE FEED

TYPE 369 IMPEDANCE

A unit suitable for use in parallel plate feed systems.

Price $5.00

Are you troubled with motor-boating in your audio frequency amplifier—or perhaps you have purchased a pair of really good audio frequency transformers and after placing them in use, find that results are not quite up to your expectations? If your tubes and plate supply are functioning properly your trouble can, in most cases, be eliminated by the use of parallel plate feed. A folder describing the advantages of this system will be sent on request.

GENERAL RADIO

We welcome your correspondence in regards to technical problems. Bulletin No. 929, describing our complete line of Radio parts, will be sent on request.

30 State St., Cambridge, Mass. 274 Brannan St., San Francisco, Calif.

Master the Code

Wireless or Morse—at home with the Teleplex Automatic Code Instructor. No better method for self-instruction exists. Quick—Easy—Thorough. Endorsed by U. S. Navy. The only instrument that Reproduces actual sending—messages, Radiograms, etc. Any speed. Complete Course (6 tapes) FREE. Thirty times as many words as any other instrument. Avail yourself of the Teleplex for a quick mastery of the code. Write for booklet BR. TELEPLEX CO., 76 Cortlandt St., New York.

This is a good time to subscribe for RADIO BROADCAST
Through your dealer or direct, by the year only $4.00
DOUBLEDAY, DORAN & COMPANY, Inc., Garden City, N. Y.

RADIO PANELS

BAKELITE—HARD RUBBER

Cut, drilled and engraved to order. Send rough sketch for estimate. Our complete Catalog on Panels, Tubes and Rods—all of genuine Bakelite or Hard Rubber—mailed on request.

STARRETT MFG. CO.
521 S. Green Street Chicago, Ill.

FROST RADIO

FROST-RADIO

Frost Variable High Resistances

Think of a variable high resistance with a marvelously smooth regulation over entire range of resistance strip, free from friction and almost totally without wear, due to roller contact arm. No jerks—no jumps—no dead spots—no sudden increases or decreases in volume. Just stepless, perfect regulation. Has Bakelite shell and cover, and engraved Bakelite pointer knob. Adopted as standard by leading set manufacturers, and countless thousands are in use in home built sets. Supplied in two or three terminal type, in wide range of resistances from 2,000 to 500,000 ohms, and with or without switch. 2 or 3 Terminal Type, less switch, $1.75. 2 or 3 Terminal Type, with switch, $2.10.

HERBERT H. FROST, INC.
Main Offices and Factory
Elkhart, Ind.

BROADCASTING FROM THE INSIDE

EVERY month in RADIO BROADCAST appears the departments "As the Broadcaster Sees It," written by Carl Dreher, one of the best known broadcast engineers in the country. Alive with humor, news, apt and searching comment, Mr. Dreher's writings have become one of the most popular features of radio writing anywhere. Are you reading it? Subscribe by the year and make sure of not missing a single issue. Mail your check for $4.00 to Subscription Department, Doubleday, Doran & Co., Inc., Garden City, N. Y.

Fixed Voltage *means* Variable Resistance!

Variables exist in any radio circuit. You correct them by changing the controlling resistance. If you want fixed voltages, use the

CLAROSTAT

Reg. U. S. Pat. Office

Self-Adjusting!

For best performance your tubes require a variable filament control to supply the definite current they need, despite "A" battery variations. AMPERITE is the only self-adjusting and automatic filament tube control that does this. Takes the "guess," inconvenience and unsightliness out of panel rheostats. Simplifies wiring, panel design, and tuning. Prolongs tube life. Order by name. Accept nothing else. Price $1.10 mounted (in U. S. A.) For sale by all dealers. ***Write for FREE "AMPERITE BOOK" of season's best circuits and latest construction data. Address Dept. R.B.-6.***

RADIALL COMPANY
50 Franklin St., New York

AMPERITE
REG. U. S. PAT. OFF.
The "SELF-ADJUSTING" *Rheostat*

DRAKE'S RADIO CYCLOPEDIA

1928 Edition, complete, up-to-date. Full information on A. C. and Screen Grid Tubes. Over 900 pages, 1025 illustrations. For Service and Repair Men, Dealers, Salesmen, Experimenters and Designers. At dealers or by mail, $6.00.

FREDERICK J. DRAKE & CO.
PUBLISHERS
1013S Michigan Ave. Chicago.

No. 198 RADIO BROADCAST Laboratory Information Sheet **June, 1928**

The Screen-Grid Tube as an R. F. Amplifier

CALCULATING GAIN

PROBLEM:—Suppose that we have a radio-frequency amplifier connected as indicated in the figure and that a screen-grid tube is used. How can we calculate the amplification that can be obtained?

SOLUTION:—To solve the problem we must make use of the tube constant known as the mutual conductance, which, for the screen-grid tube, has a value of about 350 micromhos or 0.000350 mhos. The mutual conductance G_m by definition,

$$G_m = \frac{I_{ac}}{E_g} \qquad (1)$$

where G_m is the mutual conductance in mhos; I_{ac} is the alternating current flowing in the plate circuit; E_g is the alternating voltage impressed in the grid; transposing this equation we get

$$I_{ac} = G_m \times E_g \qquad (2)$$

The voltage E_t across the tuned circuit is equal to the impedance of the circuit Z times the current through it

$$E_t = I_{ac} \times Z \qquad (3)$$

and therefore

$$E_t = G_m \times E_g \times Z \qquad (4)$$

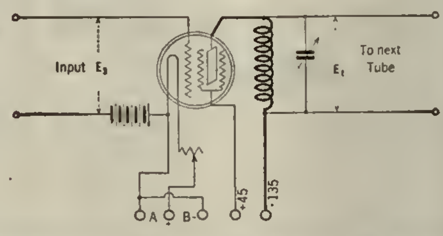
The amplification of the circuit is equal to the voltage across the output E_t divided by the voltage across the input E_g. Transposing equation (4) to get this ratio we obtain

$$\frac{E_t}{E_g} = G_m \times Z \qquad (5)$$

This equation shows that the gain of this circuit using a screen-grid tube is simply equal to the mutual conductance of the tube in mhos, times the effective impedance of the tuned circuit.

Therefore, if we know the impedance into which the tube is working, we can, by multiplying the impedance by Gm, obtain the amplification. If the tuned circuit at resonance has an effective impedance of 100,000 ohms then the amplification would be

$$\text{Amplification} = 0.000350 \times 100{,}000 = 35$$



No. 199 RADIO BROADCAST Laboratory Information Sheet **June, 1928**

Current

ITS DIRECTION OF FLOW

THE direction of flow of current around a simple circuit consisting of a battery and a resistance is generally considered to be as indicated by the solid arrows in sketch A on this sheet. As indicated, the current is thought of as flowing out of the positive terminal of the battery, through the resistance and into the negative terminal of the battery.

Now let us look at the circuit of a vacuum tube, as indicated in sketch B. In this circuit we would assume that the current would flow as indicated by the solid arrow, *i, e.,* out of the positive terminal through the tube and into the negative terminal just as it did in circuit A. However, we know that the filament of the tube is the electron-emitting substance and that the electron flow is from the filament to the plate. Apparently we have two currents flowing in the circuit, and this has led some experimenters to believe that there were two distinct currents flowing in the circuit, one the battery current and the other the electron current. This is not so and there is only one current flowing in the circuit, the electron circuit.

(A)

The idea that the electric current flows from the positive to the negative originated before anything was known about electrons. This direction of flow has since been proved to be wrong. It is now realized that an electric current is actually a flow of electrons and that electrons, being negatively charged, flow toward the point of positive potential. Therefore the actual flow of current in the tube circuit B and the battery circuit A is as indicated by the dotted arrows.

(B)

Fortunately the incorrect assumption that was made years ago for the direction of the flow of current is not important in the solution of electrical problems so long as we remain consistent regarding the direction in which the current is assumed to flow.

Many meters used in electricity are marked with plus and negative signs and the winding of the meter is arranged so that the pointer on the meter will deflect in the right direction when the positive terminal of the meter is connected to the more positive part of the circuit.

No. 200 RADIO BROADCAST Laboratory Information Sheet **June, 1928**

Resistors

DETERMINING WHAT SIZE TO USE

IN CHOOSING a resistance for any particular purpose it is necessary to determine the value required, the current it must carry and then from these two facts determine the wattage rating required. The chart published on this sheet will prove useful to determine:

(*a*) the wattage rating a resistor must have to carry a given current
(*b*) the current a resistor, of given wattage rating, will carry

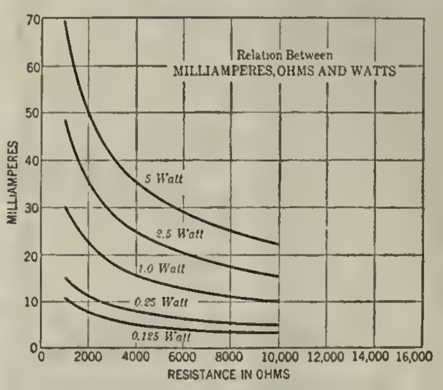
The curve is plotted to cover resistors up to 10,000 ohms and wattage ratings up to 5 watts.

EXAMPLE: A resistor is to be used to supply C-bias to a 171-A type tube. The plate current of the tube (which must flow through the resistor) is 20 milliamperes. The required C-bias voltage is 40 volts. What value of resistance and what wattage rating should the resistor have?

To calculate the required value of resistance we use Ohm's law.

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current in amperes}} = \frac{40}{0.020} = 2000 \text{ ohms}$$

Referring to the chart below, we find that the vertical line corresponding to 2000 ohms crosses the horizontal line corresponding to 0.020 amperes (20 milliamperes) at the point indicated between the curves of 1.0 and 0.25 watt resistors. In such a case we must, of course, always use the larger size and therefore in this case we should use the 1.0-watt resistor.



STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., required by the Act of Congress of August 24, 1912, of RADIO BROADCAST, published monthly at Garden City, New York for April 1, 1928. State of New York, County of Nassau.

Before me, a Notary Public in and for the State and County aforesaid, personally appeared John J. Hessian, who, having been duly sworn according to law, deposes and says that he is the treasurer of Doubleday, Doran & Co., Inc., owners of Radio Broadcast and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: *Publisher*, Doubleday, Doran & Co., Inc., Garden City, N. Y.; *Editor*, Willis Wing, Garden City, N. Y.; *Business Managers*, Doubleday, Doran & Co., Inc. Garden City, N. Y.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent. or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.) F. N. Doubleday, Garden City, N. Y.; Nelson Doubleday, Garden City, N. Y.; S. A. Everitt, Garden City, N. Y.; Russell Doubleday, Garden City, N. Y.; George H. Doran, 244 Madison Avenue, N. Y. C.; George H. Doran, Trustee for M. N. Doran, 244 Madison Avenue, N. Y. C.; John J. Hessian, Garden City, N. Y.; Dorothy D. Babcock, Oyster Bay, N. Y.; Alice De Graff, Oyster Bay, N. Y.; Florence Van Wyck Doubleday, Oyster Bay, N. Y.; F. N. Doubleday or Russell Doubleday, Trustee for Florence Doubleday, Garden City, N. Y.; Janet Doubleday, Glen Cove, N. Y.; W. Herbert Eaton, Garden City, N. Y.; S. A. Everitt or John J. Hessian, Trustee for Josephine Everitt, Garden City, N. Y.; William J. Neal, Garden City, N. Y.; Daniel W. Nye, Garden City, N. Y.; E. French Strother, Garden City, N. Y.; Henry L. Jones, 244 Madison Ave., N. Y. C.; W. F. Etherington, 50 East 42nd St., N. Y. C.; Stanley M. Rinehart, Jr., 1192 Park Ave., N. Y. C.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent. or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) NONE.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is...... (This information is required from daily publications only.)

(*Signed*) DOUBLEDAY, DORAN & COMPANY, INC.
By John J. Hessian, *Treasurer*.

Sworn to and subscribed before me this 15th day of March, 1928.

[SEAL] (*Signed*) Frank O'Sullivan
(My commission expires March 30, 1928.)

Why not subscribe to *Radio Broadcast*? By the year only $4.00; or two years $6.00, saving $2.40. Send direct to Doubleday, Doran & Company, Garden City, New York.

The Haven of a Sea-Going Audion

By RAYMOND TRAVERS

LIFE on Teraina (Washington Island) was one of complete detachment from all the rest of the world. After a thrilling ride through the surf and a safe landing on the beach, a strange sense of having been abandoned comes over you. This is followed, after a few days by a feeling of emancipation. At last life is freed from its great complications, and the mad existence of the cities is but a hazy thing of the past. Living is simplified to the fundamentals. Sleep is not only a matter of the nights but is indulged in during the hot noon-day. Food comes from cans without fuss or garnish. Eating is a necessity—not a habit. Everyone has work to perform and in so doing is called upon to exercise feats of ingenuity beyond belief. There isn't any assistance around the corner. Further and further into the background of the mind fades the worlds beyond the horizon, and greater becomes the content with the life at hand.

The steamer from Honolulu arrived about every four months (once it was nine!) and brought mail, excitement, and grief, most times. For the few days the little ship lay off the island, unloaded its cargo of food and supplies, and took aboard the tons of copra we had laboriously gathered, conditions ashore were in a state of crazy confusion. The mail had to be sorted for matters of great importance requiring immediate reply; the supplies to be checked and examined, some to be returned or complained about; sometimes distinguished guests to be entertained, when every minute was so vital to personal affairs. At last the sailing hour arrives, the ship disappears, and the last surf boat is hauled ashore. There are weary sighs, some cursing, a few drinks of gin and cocoanut, and a prayer that the blooming ship will never return!

ON THE sands behind the coral reefs of Washington Island, in the Pacific South Seas, a thousand miles south of Honolulu and five thousand miles west of Panama, an audion bulb was picked up some years ago. There was a radio telegraph station at Washington Island, and R. A. Travers was the operator. He saw the audion bulb, recognized the handiwork of the inventor, and that night put the bulb in the mail, with the following letter:

WASHINGTON ISLAND.
VIA HONOLULU AND FANNING ISLAND
December 1, 1919.

Dr. Lee DeForest,
New York City.
Dear Doctor DeForest:

I am sending you by parcel post an interesting valve I believe to be one of you pre-war types. . . . This valve traveled many miles through the Pacific ocean, bobbed over a coral reef, and came to rest on the sands of this island. . . . Washington island is a wee spot in the wide Pacific, having less than a dozen miles of coast. . . . From wreckage picked up from time to time, it appears drifting objects come from the eastward. . . . I believe this valve will be of interest in your collection.

R. A. TRAVERS.

The foregoing paragraphs appeared in an article in the November, 1925, RADIO BROADCAST as introduction to part of the history of Dr. Lee DeForest. Mr. Travers here writes his side of the story and gives an interesting description and more details of this "wee spot in the wide Pacific" where the "lost audion" was found.

Tabueran (Fanning Island) and Teraina (Washington Island), are British possessions, situated one thousand miles directly south of Honolulu, about three degrees north of the Equator, and five thousand miles west of Panama. The finest copra in the world is nutted here, but never in large quantities, because the major parts of both islands are wild, prohibiting maximum crops and efficient collection. In 1917 an Englishman was sent from London to place Washington Island on a more modern operating basis and increase production.

At Fanning is located the relay station on the Pacific Cable Board's Canadian-Australian lines. The cable from Fanning to Bamfield, British Columbia, is the longest in the world, running from the warm waters of the tropics into the slate gray, choppy and cold shallows of the north—five thousand miles! All important communications between England and the Colonies were routed over this cable, and so we find one of the notorious German raiders terrorizing the South Pacific, slipping ashore at Fanning, and with some well placed dynamite, enlarging the area covered by the cable buildings. Off-shore the cable was cut. This may have had

WASHINGTON ISLAND IN THE SOUTH PACIFIC
Here the author found the audion which had drifted thousands of miles—from where?

THE HAVEN OF A SEA-GOING AUDION

(*continued from page 116*)

something to do with the fact that in May, 1917, I left San Francisco with two 3 kw. wireless sets for the islands. A naval operator came from Sydney Navy Yard to take over Fanning and I proceeded to Washington. The grief and struggle of construction is another tale.

A manager, bookkeeper, doctor, surveyor, two half-caste overseers, myself, and about two-hundred natives set about building a settlement and at the same time gathering copra. The replacing of thatched huts by modern cottages occupied many months of labor. Every Sunday morning at about eleven o'clock, the Staff assembled and in a very dignified manner made an inspection of all work and of the native quarters. To the manager this was a serious affair executed with military severity, but to the others it was a joke, and much playing took place behind his back. A match on the floor or under a native's house was sufficient to have the offender arrested and brought before "Court" Sunday evening. Many amusing situations developed in "Court" and often the stern manager-judge "lost face". There was the case of Kabuta who refused to clean his house unless he was paid overtime for so doing. He contended that, as the house belonged to "The Company" he should be paid for keeping it clean. This brought about an impasse, and he was arbitrarily ordered to polish it up if he expected to live in it. The following morning native police reported Kabuta had not slept in his house and was absent from camp. This violated two more rules. Kabuta stated he had spent the night sleeping on boxes of dynamite in a lean-to, about a mile up the beach, where cleaning wasn't necessary.

DISCOVERING THE AUDION

ON THE morning of September 16, 1917, I experienced the same sensation as the man who saw the giraffe for the first time and exclaimed, "There isn't any such animal!" The usual inspection was in progress, and the average number of arrests being made, when my attention was attracted to a little glass ball suspended from the rafters in a native's room. Wrinkling my nose in native fashion point, I asked of the fellow squatting on the floor, "Terrah?" He shrugged his shoulders up around his ears and with a puzzled expression on his chocolate features replied, "Ungcome!" I extended my hand for the thing and he passed it to me. Imagine my astonishment to find that it was a DeForest Audion, the first I had ever seen, but recognized from pictures. I wanted to know where the native had found it and he said, "Ay naka may en tardy," ("It came here from the sea,") He had picked it up while walking along the beach and thought it a pretty bauble.

There is a native custom which forces one to give up an object if the other party desiring it merely begs for it saying, "Now! Ye pacheco." In this manner I became the owner of the tube, one of the strangest and most fragile bits ever cast ashore by the pounding seas.

Remember that this was in 1917 and I doubt if there was a handful of these tubes in the entire territory contiguous to the Pacific Ocean. Some tubular shaped Audiotrons, made in Berkeley, California, were being used. I had a dozen myself.

The question as to where this Audion could have come from was a difficult one to answer. Teraina was 900 miles from the Australian sea-lanes and 1800 miles from the courses to Tahiti. Honolulu was the nearest port and that was a

(*continued on page 118*)

THE HAVEN OF A SEA-GOING AUDION

(continued from page 117)

thousand miles to the north'ard. Allowing a drift of but a few miles a day, many months must have passed and miles unwound from the point of departure until riding the surf, this tiny glass bulb found rest on the sands at Teraina. Study of other drift material offered the only opportunity for conjecture.

Cocoanuts are supposed to have come from Central America and vegetated throughout the South Pacific. While digging an irrigation canal on Washington Island, an old Manahikian canoe was found. It was quite a distance inland from the present shore of the lake and buried in gravel, which undoubtedly was the old lagoon beach, before the present lake was formed by the lagoon's closing. The bow is in good condition and now occupies a prominent position in the Bishop Museum, Honolulu. There are legends told by the old men of Manahiki, about travels to Teraina in great canoes. One tale recites how the King of Manahiki, angered at some of his people who refused to return from Teraina, cursed them and cried for a tidal wave to wipe out the rebel village. The canoe is pointed out as evidence of Manahikian occupation and the closed lagoon as the fulfillment of the curse.

Of more recent date is a load of lumber consigned to A. P. McDonald, Tahiti. This must have been washed overboard from some schooner and found its way to Fanning and Washington. Fanning is 75 miles to the southeast of Washington. The lighter pieces came ashore at Washington while all the great, heavy beams piled up on Fanning, without exception. The British Commissioner at Fanning seized the lumber for his new house, quoting a law some hundreds of years old, which claims everything from the sea for the Crown.

Standard Oil Barge No. 95 almost foundered off the coast of lower California. Everything on deck was swept away. A year and a half later, one of her steel lifeboats, buoyed by the airtight compartments in bow and stern, majestically floated past our island. An object resembling a human head was visible, silhouetted against the bright noon-day sky. Dave Greig, the overseer, and I were the only ones at the settlement, except the cooks and store boys. Greig launched a small fishing boat and started to run down the visitor. What suspense as I stood on the beach and watched him overtake the lifeboat! Then he gave me the prearranged signal that there wasn't any one aboard. After quite a struggle against the strong current, Greig succeeded in bringing the boat ashore. We were surprised to find it nearly full of water and with a great many fish of all sizes swimming about. The bottom was filled with fish bones, who had perhaps served as food for later comers. Many of the bones were from large sharks. This craft must have come at least 5000 miles, and as it is highly improbable that it traveled anything like a straight course, the distance must have been many times that.

All of this drift has been from the eastward and in each case, except the audion, a point of origin is known. It is possible that the DeForest wanderer started somewhere in the Atlantic, bobbed through the Canal, crossed the Pacific, and came to rest, at last, on the beach at Teraina. This is not any more difficult to believe, than the mere fact that it came out of the sea, over a rocky reef, to the beach—a beach whose entire length is but eleven miles, situated in mid-Pacific where distances are measured in thousands of miles!

The cocoanuts, the canoe, the lumber, the lifeboat, and the DeForest Audion—symbols of an age, and slender threads from other worlds—to peaceful, detached Teraina!

RADIO BROADCAST. July, 1928. Published monthly. Vol. XIII. No. 3. Published at Garden City, N. Y. Subscription price $4.00 a year. Entered at the post office at Garden City, N. Y., as second class mail matter. Doubleday, Doran & Company, Inc., Garden City, N. Y.

RADIO BROADCAST

JULY, 1928

Willis Kingsley Wing, Editor
Keith Henney, Director of the Laboratory
Edgar H. Felix, Contributing Editor

Vol. XIII. No. 3

CONTENTS

The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

AMONG OTHER THINGS. . .

MANY favorable comments have been received about the list of stations throughout the world transmitting below 100 meters which occupied three pages of our May, 1928, issue. Although this list was very carefully checked for accuracy against the best lists of stations we could find, some errors undoubtedly crept in. Some of our readers have been kind enough to send us information which should be included when the list is published again in Radio Broadcast. In the course of the next four or five months we shall reprint the list, completely revised. We urge our readers to help us by sending in any corrections which should be included at that time.

IN THIS issue we begin a new feature, "Radio Broadcast's Home Study Sheets" prepared by Keith Henney, director of the Laboratory. Back in September, 1925, Mr. Henney's first article, "New Fields for the Home Experimenter" undertook to lead the radio experimenter who had tired of merely building radio sets and who desired to learn more about what makes the wheels go 'round. Since that time, many articles of a similar nature have been published in these pages. With this issue we begin the "Home Study Sheets," which are arranged so that the interested readers can remove them with a razor blade and keep a complete file. The Sheets to follow will contain a great deal of practical information in what we believe is the most useful form. We shall be glad to have our readers' opinions on the innovation. It is a policy of Radio Broadcast to print as much useful information as possible with due thought to the form in which it is presented. The "Lab Sheets"—the 208th appears in this issue—were the first in this series. Next follow the "Service Data Sheets on Manfactured Receivers" and we have now added the "Home Study Sheets." Still other services, similarly valuable, are in prospect.

UNLESS we are greatly mistaken, several of the articles in this issue are going to excite a great deal of interest. The leading article by R. P. Clarkson, "What Hope for Real Television?" attempts to explain television systems in general and to point out what now seems to be the only possibility of success.

OUR August issue will contain, among other things, a description of the d.c. operated "Lab" circuit, another timely article on television, a really fine article by David Grimes on phonograph pick-up units, a constructional and operation article on the Cooley Rayfoto system, first introduced to our readers in our September, 1927, issue, a story on a new short-wave receiver, and the first article of a series by Robert S. Kruse. Mr. Kruse for a number of years was technical editor of *QST*. His first article deals with the mystery of 5-meter work and will be of especial interest to all our amateur friends who read Radio Broadcast. All the regular features will appear in our August issue as well.

AS THIS issue goes to press, a correction has been noted in the list of parts (p. 142) for the article "A Good Amplifier-Power Unit for the 250 Tube" The Dongan Condenser Unit, C1, is listed at \$16.50, instead of \$23.00, as printed in the list.

—Willis Kingsley Wing.

DOUBLEDAY, DORAN & COMPANY, INC., Garden City, New York

MAGAZINES
Country Life
World's Work
Garden & Home Builder
Radio Broadcast
Short Stories
Educational Review
Le Petit Journal
El Eco
Frontier Stories
West
The American Sketch

BOOK SHOPS (Books of all Publishers)
New York: Lord & Taylor; James McCreery & Company; Pennsylvania Terminal and 166 West 32nd St.; 848 Madison Ave. and 51 East 44th Street; 420 and 526 and 819 Lexington Avenue; Grand Central Terminal and 38 Wall Street
Chicago: 75 East Adams Street
St. Louis: 223 N. 8th St. and 4914 Maryland Ave.
Kansas City: 920 Grand Ave. and 206 West 47th St.
Cleveland: Higbee Company
Springfield, Mass: Meekins, Packard & Wheat

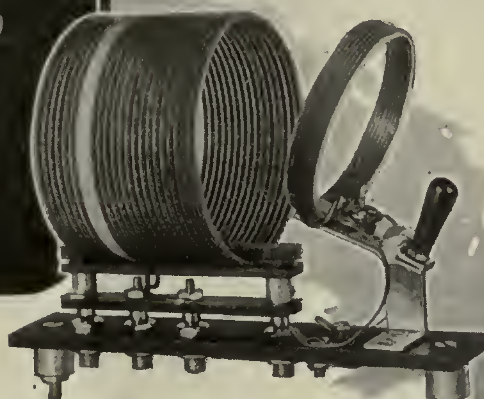
OFFICES
Garden City, N. Y.
New York: 244 Madison Avenue
Boston: Park Square Building
Chicago: Peoples Gas Building
Santa Barbara, Cal.
London: Wm. Heinemann, Ltd.
Toronto: Doubleday, Doran & Gundy, Ltd.

OFFICERS
F. N. Doubleday, *Chairman of the Board*
Nelson Doubleday, *President*
George H. Doran, *Vice-President*
S. A. Everitt, *Vice-President*
Russell Doubleday, *Secretary*
John J. Hessian, *Treasurer*
Lillian A. Comstock, *Ass't Secretary*
L. J. McNaughton, *Ass't Treasurer*

TERMS: \$4.00 a year; single copies 35 cents.

New Hammarlund *Space-Wound* COILS

For Low-Wave and Screen-Grid Circuits



For LOW-WAVE RECEPTION

20, 40 and 80 Meter Bands

Set of Three Coils and Plug-In Base. . $10.00 complete
Plug-In Coils. . . . . 2.50 each
Base Only . . . . 3.00 "
Special Plug-In Coils for higher wave-lengths.

Write for interesting low-wave folder

LOW-WAVE INDUCTOR COILS

20, 40 and 80 Meter Bands

Set of Three Coils and Plug-In Base. . . . . $6.00 complete
20 and 40 Meter Coils. . . $1.50 each
80 Meter Coils. . . . . 2.00 "
Base Only. . . . . 1.00 "
Special Plug-In Coils for higher wave-lengths.

Amazing results now obtained by experimenters with low-wave reception provide real thrills for the radio fan. The new Hammarlund Plug-In Coils insure the utmost efficiency in low-wave work.

Secondary and tickler are space-wound on a film of high-test dielectric material. Losses are low. Results are exceptional. A set of three coils with plug-in base (base includes variable primary coil with flexible phosphor-bronze connections) covers the 20, 40 and 80 meter bands, with a range from 15 to 107 meters. Special coils available for higher waves.

Hammarlund Low-Wave Inductors for R.F. stages, using either standard or screen-grid valves, are now also provided with plug-in base for convenient change to any wave-length from 15 to 107 meters. They are constructed like the coils described above, without tickler or variable primary.

The remarkable efficiency of the new screen-grid valves is further increased when used with Hammarlund No. 222 Coils, specially designed for screen-grid circuits covering the broadcast range. A feature of both the antenna coupler and R. F. transformer is the four-tap primary, which allows the greatest amount of coupling consistent with selectivity required. Only two inches in diameter, they may be mounted vertically within shields or other small space. The antenna coupler may be used also for other standard circuits, where great latitude of primary coupling is desired.

No. 222 COILS

For Screen-Grid Circuits

Antenna Coupler and R. F. Transformer, each with four taps on the primary coil. Two sizes, for use with .00035 and .0005 condensers. . . . .$2.50 each

If your dealer can't supply you, write direct to us. Ask for Hammarlund literature.

HAMMARLUND MANUFACTURING COMPANY
424-438 W. 33rd Street, New York

For Better Radio
Hammarlund
PRECISION
PRODUCTS

A Giant British Radio-Equipped Passenger Airplane

THIS is a close-up of one of the giant DeHavilland 66 Hercules multiple-engined airships, fitted with three Bristol Jupiter 450-horsepower engines, built for the British Imperial Airways for the new passenger air route between England and India via Egypt, Palestine, Mesopotamia, and Persia. The radio cabin is the most spacious yet fitted in any airship and contains the best apparatus now available. Under the new international aerial regulations, a radio operator and mechanic is carried to attend to the apparatus and operate it. Previously the radio equipment was carried in the cockpit and operated by the pilot. The power of the transmitter is 150 watts. The set is slung on elastic bands to reduce vibration; the wind-driven generator, minus its propellor, is visible just under the top wing

BEFORE THE BAIRD "TELEVISOR"

In spite of the miles of type expended on television, it is not yet possible by any known system to receive images which have much detail. All the systems known are generally similar. Although it is possible for experimenters to construct simple receivers to pick up television signals, "when, as, and if" transmitted, the results are difficult to achieve. The illustration shows Mrs. Howe, said to be the first woman whose features were "televised" across the Atlantic by the Baird system

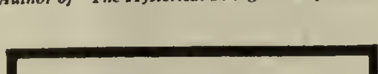
What Hope for Real Television?

By R. P. CLARKSON

Author of "The Hysterical Background of Radio"

THE promise of television is that we may see events as they occur, no matter where we are, provided we have a television receiver and provided, also, that a televisor operator is present at the event. Televising is the broadcasting of images, the annihilation of distance for the eye as aural radio has done for the ear. In place of the microphone we want to use the camera lens together with some device that translates light reflected from the object, into electric current impulses which speed to our receiver where those impulses are translated back into light and are projected on a screen

This is the promise. It seems so simple. Yet long before regular broadcasting of programs commenced, we were as far ahead in method as we are now. It violates no confidence to say that only within the last month one of the most prominent workers has abandoned the problem in favor of research on the facsimile transmission of telegrams. Another, C. Francis Jenkins, writes that it is a stubborn problem but the solution seems to be right around the corner. In England, Sir Oliver Lodge raises a note of warning against the public expecting success, stating that other scientists are in accord with him. Theodor Nakken, whose researches have made the photoelectric tube available for this work, states flatly that the thing is impossible with the methods now being tried, except at enormous costs. With this weight of authority against success, let us look for a moment at the problem.

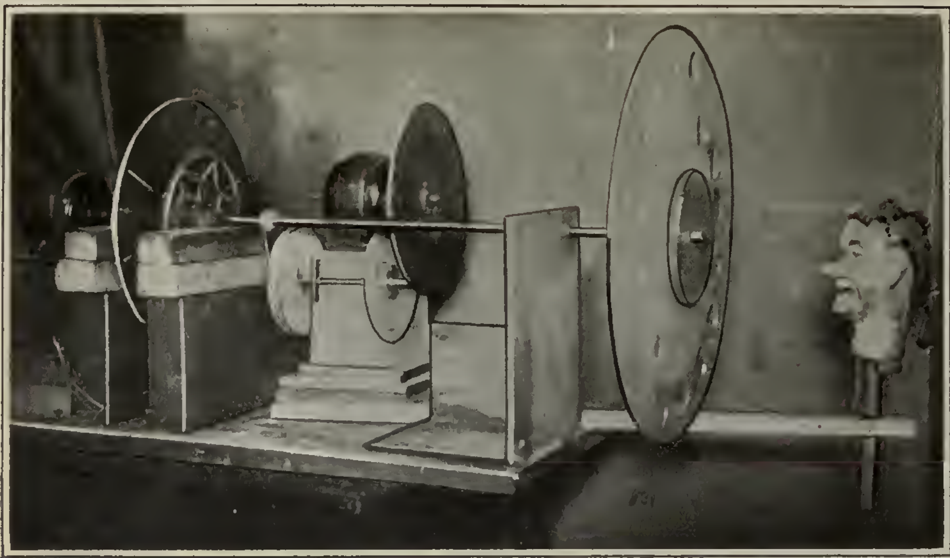


EIGHTEEN LINES TO THE INCH

This drawing shows what slight modulation is required to portray the features. The image received in some television outfits is no larger than the actual size of the cut above. The reader may imagine the detail of the received picture where the image of an entire head, for example, must be included in this space

The eye is a camera, but a very defective one. It retains an impression for a definite period, normally about one-tenth of a second, and because of this, moving pictures are possible. On the other hand, an impression must affect the eye for a certain definite minimum of time, depending upon the intensity of light, or it won't register in the consciousness at all. This makes possible the magician's tricks in dim light, and makes almost impossible the achievement of television.

To see any image dot by dot, the first essential is that the eye must see each dot for a period long enough to awake the consciousness, and yet it must see the last dot of the image before the impression of the first dot is lost. To put this in figures means that the last dot must be shown within a tenth of a second after the first dot, and yet each dot must appear for at least the five-hundred-thousandth part of a second, strongly



BAIRD'S FIRST "TELEVISOR"

This crude but workable apparatus, undoubtedly the result of much labor on the part of Baird, who, like most inventors dependent upon their own resources, had very little money with which to carry on his experiments, gives an idea of how simple is the essential apparatus required for the production of television signals. The various disks function to break up the object to be transmitted into many tiny dots so that the light finally reaching the photoelectric cell is broken up into many consecutive impulses each of which corresponds in intensity to one particular spot of the subject. This original model has been placed on view at the Science Museum, at South Kensington, London

illuminated. These two figures determine the size and quality of the possible image. They indicate 50,000 dots to the picture as substantially the possible maximum and strong artificial illumination as essential at the receiver, unless some way is found to maintain the illumination of the dots beyond the period of their stimulus.

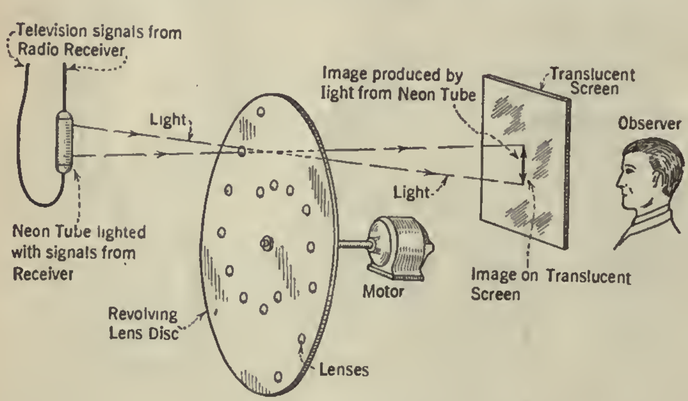
Transmitting an image and transmitting a musical composition are accomplished in the same way. The music is sent note by note in ordered sequence. We enjoy it as it is produced. A picture is similarly subdivided into dots of light and shade and these dots sent in any sequence, but they must all be received and placed in proper relationship before there is any picture. There is nothing to see until the transmission is ended. In telephotography, time is no bar to transmission because each dot is permanently recorded as received, and when transmission is ended we have a complete record. In television, each image is fleeting. There is no record. It is all over in a tenth of a second and the next image is on the way. Time is of the essence of television. It is largely the problem of time that makes successful telephotography meaningless with respect to television. A small picture sent in five minutes is commercially perfect but to send 3000 pictures of the same size in the same length of time is another story.

REQUIREMENTS OF A GOOD PICTURE

NEGLECTING color and form, for the moment, all pictures and images differ from each other only in the distribution of light and shade. The range of light intensities is of the order of one to thirty, as we go from deepest shadow to brightest light. But all these intensities are not usually sharply defined. They may shade into each other abruptly, however, as in the case of a church steeple standing out against a white cloud. Draw an imaginary line across the steeple and follow in your mind the changing light and shade along that line. From the white of the cloud you may change suddenly to a very dark edge of the steeple, and then come a continual series of changes through all shades as the detail of the steeple is recorded. Across a peaceful landscape even greater variations may be found as you follow a straight line through clouds, trees, leaves and grasses, flowers, dirt, stones, pebbles, and whatnot. These changes in light and shade are the "modulation" of the picture.

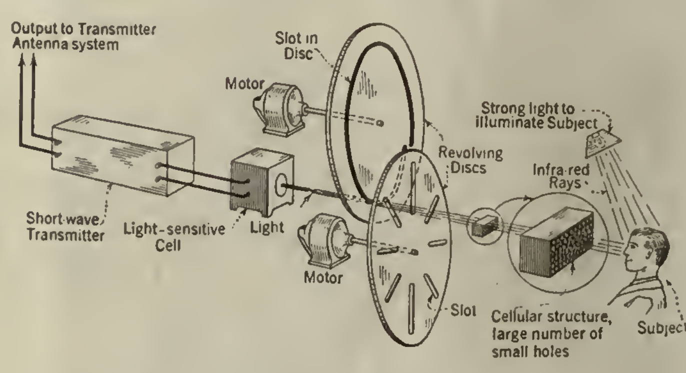
Long experience with half-tones has shown that to produce a really good picture, provision must be made to reproduce 130 to 150 changes in light and shade to each lineal inch. This same modulation may be required up and down a vertical line as well as sideways along the horizontal. In other words, the modulation figure for a square inch may be of the order of 20,000 changes. If the figure is made up of dots, 20,000 of them have to be printed to give the detail of a fine half-tone. On cheap news print, where the surface itself is rough, as low as 2500 dots per square inch are used in the poorest of newspaper reproductions. Most of the New York papers use 3969 dots per square inch, while this magazine and other popular ones on good paper uniformly use 14,400 dots to the square inch. Even with the highest of all these figures, however, details of cloud effects cannot be reproduced and the beautiful lights and shadows of woodcuts are impossible.

In our television screen image let us aim no higher than the detail of a news print photograph. For each square inch of the picture there must be 2500 dots transmitted. For an image one foot square, which wouldn't give much of a view of a spectacle such as a ball game, there would be 360,000 dots. The last dot must arrive within a tenth of a second after the first dot, so the rate of transmission over a single waveband would be 3,600,000 dots or impulses per second. Each dot would exist only that small fraction of a second



BAIRD'S TELEVISION RECEIVER

This shows the arrangement of the revolving disc, neon tube and translucent screen used in one model of the Baird television receiver. The light from the neon tube, varying in accordance with the picture signals, passes through the lenses in the revolving disc (which must rotate in synchrony with the transmitting apparatus) which focus the light on the screen; the image is viewed from the opposite side of the screen. The general system used here is very similar to that used by Dr. E. F. W. Alexanderson of the General Electric Company in his recent demonstration at Schenectady. The only difference was that the lenses in the disc and the screen were dispensed with and the observer saw the image by looking at the neon tube directly through the revolving disc. The received image is red in color—a characteristic of all television reception using neon tubes, with their characteristic red glow

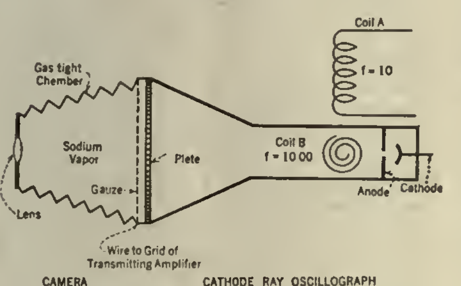


THE BAIRD "TELEVISOR"

This transmitter, the result of experiments by J. L. Baird, makes use of infra-red rays, invisible to the human eye, but capable of affecting the photoelectric cell which converts the varying light signals into corresponding electric impulses. The infra-red rays, reflected from the subject transmitted, pass through the cellular structure which breaks up the light into many small sections or dots. The light then passes through the two revolving discs which rotate in such a manner as to expose to the light-sensitive cell at any moment only one of the light beams from the cellular structure. The resulting electric impulses are then caused to modulate the radio transmitter. The use of infra-red rays is not essential to the operation of this camera. Electrically, the system will function satisfactorily with any type of rays to which the photoelectric cell will respond. The amount of illumination required is quite intense, however, and, if ordinary lights were used, one would not be able to endure the intense glare for very long

and would obviously never register on the eye unless it happened to be repeated in successive pictures, and possibly not then. It would be so repeated, of course, unless motion had ensued in the intervening tenth of a second If there had been motion that part of the picture would be blank. This is the first difference we find between motion pictures and television. In the movies we see a blow start and see the arrival of the fist. We imagine the rest of it just as we see the successive positions of a speeding automobile and imagine the continuity. Only by speeding up the camera to get intervening snaps and presenting them in slow motion do we get detail. Each complete picture flashes at once. In television, because of subdivision into dots, only one dot is shown at a time and the mind will not retain this short flash during the remainder of the picture. We must make the screen retain the dot for us.

A second distinction comes from the fact that we cannot enlarge the picture received in television with any increased detail in the result. We have chosen the minimum number of dots per square inch to give a passable image. If this is enlarged by a projecting lens, we simply separate the dots. If we magnify the size ten times we'll have only 250 dots per square inch and only at a distance will this give the effect of a photograph. We haven't even the value of a printed half-tone where the dots are of varying size and shape as well as shade. Our dots are uniform except in shade.. This may be overcome by the screen in the device described later.



THE SWINTON-CLARKSON TELEVISION CAMERA

In this device the person or object to be televised is located in front of the lens, the lens functioning to focus the reflected light from the object onto the plate. A stream of electrons from the cathode is attracted to the positively charged anode and a great many of the electrons pass through the hole in the anode plate and reach a group of photoelectric cells. In passing through the space between the hole in the anode and the plate the electrons come under the influence of the two coils A and B; coil A causing the stream to be deflected up and down the plate and coil B causing the stream to move back and forth across the cells. The image on the plate is scanned in this manner

Now, getting back to the 3,600,000 impulses per second. This is equivalent to the modulation frequency in aural radio. The minimum frequency of the carrier would be about ten times that, or a frequency of 36,000 kilocycles, approximately eight meters. A larger picture or a better picture would drive us down to still shorter waves.

A FOUR-INCH SQUARE IMAGE

SUPPOSE, instead of a foot square, we make the image four inches square. Even this would mean 40,000 dots for each picture or 400,000 impulses per second. Our carrier maximum would be 75 meters. Even suppressing one side band, the 400,000 modulation frequency calls for a receiver to amplify evenly over a band of 400 kilocycles or as much as 40 of our present broadcast channels. This is for a tiny picture of poor quality and minimum speed. For any fast event, for a larger picture, or for even newspaper quality, what a complex receiver must be devised! One such station would blanket the entire broadcast spectrum.

Go down in size and quality, if you will. A three-inch square picture with 25 modulations to the lineal inch or 625 dots to the square inch, means only 56,250 impulses per second. The carrier could be as high as 535 meters but our tuning and amplification would be over five channels 10,000 cycles wide. To get within the legal separation of stations we can use a modulation of only 5000 impulses per second which, for a barely recognizable image, would give us only one square inch, remembering that we must send 10 pictures a second.

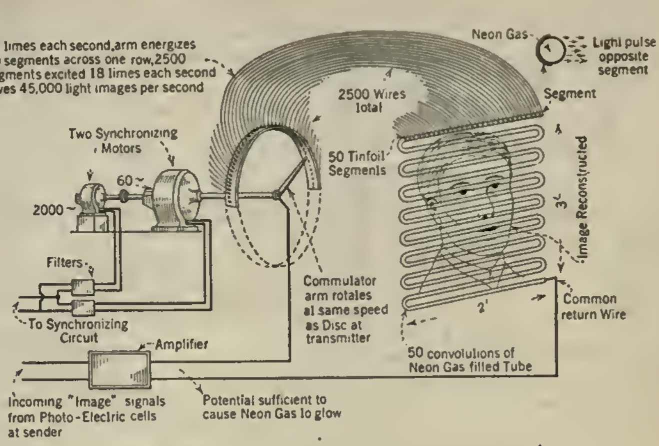
What, then, is Baird in England doing, for example? Obviously the only thing he can do and basically the only thing that has ever been done in television. That is, to select as the object to be televised, something that has few gradations of light and shade and extremely slow movement. This is the human face. It is a familiar object, almost entirely white space with the shadows around eyes and nose very ill defined and their outline of no particular importance in recognition. The cartoonists have taught us that we need no detail of a face to recognize the person. There is always some outstanding characteristic that suffices. Slight blurring would rather soften the result instead of spoiling it.

Television is not achieved merely because seeing faces at a distance has been and will be accomplished. It was in recognition of this fact that the English publication *Popular Wireless* unsuccessfully sought to induce Baird to televise a simple cube in slow motion to win the sum of $5000 that magazine offered. That Baird ignored the challenge must merely mean that he, too, recognizes the limitations of his apparatus.

There are other problems besides that of time in its relation to the defects of vision. There is the question of synchronizing the mechanically moving parts of transmitter and receiver. When things happen in the hundred-thousandth part of a second, there is need for absolute accord on both ends of the line. If the same power line is available at both ends, synchronous motors may be kept in step, but this exists only in few localities and over short distances. Synchronizing by this means it is not a real solution of the problem.

THE REAL DIFFICULTY

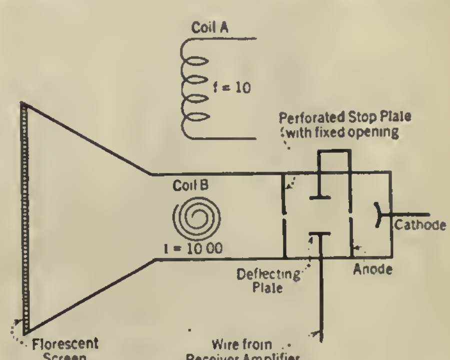
AS THIS brief review indicates, the real drawback is the fact that the picture must be subdivided and sent as a sequence of impulses. We would face similar difficulties with sound broadcasting if, for example, we had to send the whole of an opera selection as one blare of noise in a tenth of a second. It could be done, of course, by securing a sufficient number of musicians so that each need sound but one note. Then, at a given signal, every musician in this enormous orchestra would sound his note and go home. We would receive the opera selection but it would hardly be worth while. Yet this is exactly what the eye demands in television.



THE BELL TELEPHONE LABORATORIES' TELEVISION RECEIVER

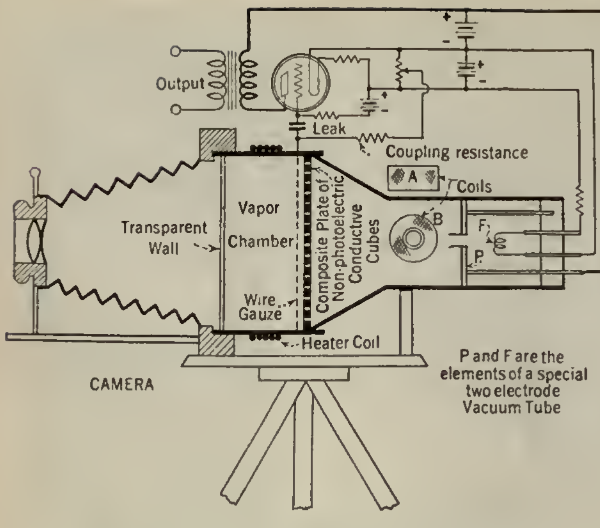
A large neon tube forms the basis of this television receiver. On the back side of the tube 2500 segments of tin foil are cemented, connecting by means of individual wires to 2500 segments on the commutator, which revolves in synchrony with the apparatus at the transmitter. The incoming signals, modulated in accordance with the shading of the subject being transmitted, are amplified and cause segments of the neon tube to glow with a brilliancy dependent upon the shading of the subject being transmitted

One thought has been to divide the object into units. That is, in terms of pictures, not to send the whole picture over one carrier but, in effect, send, say, 144 pictures, each an inch square, and at the receiver these would make up into a single image one foot square. This was one of the first ideas suggested as long ago as 1880. Carried to its extreme, perfect results would be achieved but, within the limits of costs and apparatus, we merely multiply our troubles. Sixteen pictures 3 inches square might be managed if we could send anything but a crude 3-inch-square picture. It would be at 16 times the cost and 16 transmitters as well as 16 receivers would be needed and all would have to be synchronized. Along similar lines was Doctor Alexanderson's bundle



CAMPBELL SWINTON TELEVISION PROJECTOR

This television projector, sometimes called a television receiver, uses an arrangement similar to that incorporated in the Campbell Swinton camera suggested in 1908. The electron stream from the cathode is caused to scan the fluorescent screen due to the action of the coils A and B, their intensity being varied by means of the two deflecting plates. Potential from the receiver amplifier is impressed on the deflecting plates and causes the number of electrons passing through the opening in the stop plate to vary in accordance with the image signals from the transmitter. The screen at the left of the camera becomes fluorescent under the action of the electron stream and the image then becomes visible to any one standing in front of the screen



THE CLARKSON TELEVISION PROJECTOR

This projector makes use of a three-electrode tube, the grid of which functions to control the electron stream from the filament F. The electrons passing through the opening in the plate P are caused to scan the screen due to the action of the two coils A and B. A phosphorescent screen (rather than a fluorescent screen) is used so that the screen will continue to glow for an interval after the impulse stimulus is removed. This results in considerable improvement for it reduces the amount of light required and also permits the use of a greater number of impulses so that greater detail may be obtained

of seven light rays analyzing the object, instead of one, and Doctor Ives' experiment with subdivided photoelectric cell and screen.

The Englishman, A. A. Campbell Swinton, in a letter to *Nature*, June 18, 1908, and more in detail in his Presidential Address to the Röntgen Society, November 7, 1911, set forth the genesis of an idea along these lines but one never given publicity and never tried out. I have taken the liberty of modifying this idea and present it herewith as a last desperate hope.

IS THIS THE WAY OUT?

IN ALL other television devices before the public at present the method of telephotography is being used, speeded up to the tenth-second requirement. At the transmitter is a photoelectric cell. A beam of light explores the object to be "televised" and is reflected to the cell. This cell modulates the carrier wave, just as though it were a microphone. Varying light actuates it just as varying sound actuates the microphone. At the receiver, in place of the loud speaker, is a glow lamp—usually a neon tube in one form or another—which changes its brilliancy in step with the received impulses from the photoelectric cell. The light from this lamp is made to explore a screen in synchronism with the beam at the transmitter. The usual method of swinging the beams of light up and down and over the object and screen, is a mechanically revolving disc perforated spirally with holes, a device patented by Nipkow in 1884, this inventor being the first to see the advantage of breaking up a picture into lines.

In the Swinton method there is no mechanically moving part. The object is illuminated strongly and we have a "television camera," let us say, which projects the image to be transmitted, not on a film, but on a composite plate made of tiny cubes of photoelectric material insulated from each other. The camera is gas tight and filled with sodium vapor, which conducts negative electrons more readily under the influence of light. Between the projecting lens and the composite plate, in the vapor chamber, is a gauze wire screen. The charge on this gauze screen modulates the transmitting tube.

In effect, the gauze screen is connected by radio to a plate in the receiver projection apparatus. A beam of cathode rays is directed past this plate towards a sensitive fluorescent screen. Only when the rays are slightly bent by the repulsion of the plate can they pass through a fixed opening and actually be directed to the fluorescent screen to cause a luminous spot.

At the transmitting end there is also a cathode-ray beam continually searching the composite plate of the camera but on the back side from where the image illuminates it. As this stream strikes each little photoelectric cube, it charges it negatively but the charge is dissipated unless that cube is illuminated on the front by light from the object. In the latter case, the charge of the cube will pass away through the ionized vapor along the illuminating beam of light until it reaches the gauze screen, whereupon that charge becomes an impulse carried over to the receiver projection apparatus where it charges the deflecting plate which bends the synchronized cathode ray so that a luminous spot is formed on the fluorescent screen.

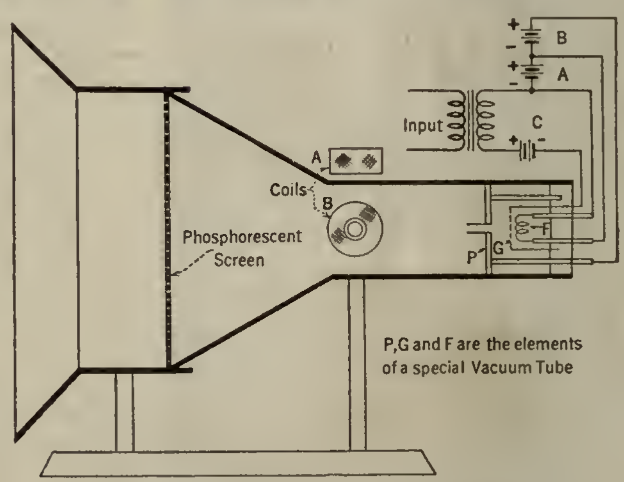
Each received impulse must correspond in position to the illuminated cube of the composite plate, requiring the synchronizing of the two cathode ray beams. This may be done at each end separately through the same construction as the cathode ray oscillograph, the beam being moved by the magnetic field of two coils at right angles to each other and having widely differing frequencies as 10 and 1000 cycles or 10 and 10,000 cycles. Substantially the two rays are merely tracing curves of great amplitude and rather low frequency.

In this method the object itself is not explored but its projected image is automatically subdivided by the composite plate of the camera, which has no electrical connections. Only one carrier wave is required but we still have the broad band of frequencies to detect and amplify at the receiver. No mechanically moving parts are used. A telephoto lens, a wide angle lens or any usual camera arrangement may be used at will. Synchronizing presents no difficulties and the method is as adaptable to wire as to radio. But as yet it has not been found practical, the main reason being that the use of photoelectric material in the composite plate means that electrons will be given off continually as long as light falls on the plate, and in mass when the image shifts.

In the writer's proposed modification of the Swinton device, the material of the composite plate is non-photoelectric but conductive. The writer uses a closed electric circuit of which the exploring electron beam is a part, the conductive cube is a part when the beam strikes it, and the ionized path in the vapor is the varying part of the circuit. An amplifying tube is readily coupled to this circuit.

In the projector proposed by the writer, he suggests the use of a three-electrode vacuum tube, using a heavily biased grid, the incoming signal modulating that grid, as usual, and permitting the flow of an electron beam. The observing screen must be phosphorescent, instead of fluorescent. That is, it must glow for a time after the impulse strikes it.

If any method within our knowledge has possibilities, this is it. If it fails, television will await the genius who conceives some new way of breaking up an image. There is no other hope.



THE CLARKSON TELEVISION CAMERA

In this arrangement a closed electric circuit exists from the source of electrons F through the beam of electrons, which act as a flexible conductor, to any conductive member of the non-photoelectric composite plate, through the plate to the wire gauze screen, along the screen to the coupling resistance and back to the filament circuit. The object to be televised stands in front of the lens at the left

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

Aviation Must Come to the Use of Radio

"THE question of wireless received serious consideration," wrote Commandant James C. Fitzmaurice in the New York *Times*, after the first westward airplane flight across the Atlantic, "but it was decided that an efficient and useful wireless set would weigh approximately 180 pounds. It was decided that this weight of benzol would be better. This was the one weak point in the organization of the flight, as we now realize that had we had a wireless set on board, upon our estimated arrival in the neighborhood of Newfoundland, we could have been given almost our exact position by the direction-finding stations along the coast and informed of the precise direction and velocity of the wind over the area, and we would have made New York easily and accomplished our objective. We consider wireless absolutely necessary for all future undertakings of this nature."

If radio could have enabled the German fliers to reach their goal, it may be argued with equal force that Nungesser, Coli, Hinchcliffe, Hamilton, St. Roman, and the other transatlantic fliers might well have made safe landings, guided through the hazardous Newfoundland region by compass bearings from Cape Race, Belle Isle, and Chebucto Head. Had the *Bremen* been properly equipped with radio, she would have landed in an airport and Floyd Bennett's tragic flight to aid the German aviators would have been unnecessary. Last year, the *Bremen* started a westward flight across the Atlantic but, warned by radio of unfavorable weather, returned to safety. Byrd's transatlantic flight was successful largely because of radio beacon signals although he did not make the most of his installation. Those who attempt long-distance flights without the aid that radio can give them, heroes or not, are both unscientific and foolhardy. The fact that some succeed in their undertaking without radio is no justification for recklessness.

Only when transatlantic and international flights become common and scheduled occurrences will long-distance flying take its place among the useful arts of human society. Like radio, aviation must become a regular service which is expected to function satisfactorily and without failure.

The scientific development of aeronautics has already advanced to the point where we have aircraft and aircraft motors which are entirely serviceable and reliable. Ships can be built to meet almost any reasonable requirement. Motors are still uneconomically shortlived, but their limitations are so well known that an ample factor of safety for any reasonable flight can be provided.

The principal obstacles to everyday use of aviation are safety and cost. When the problem of safety is solved, the public will so quickly accept the airplane as a means of rapid travel that the cost of flights will fall to a point justified by the time which they save. Public confidence, based on reliahle service, rather than spectacular feats, is the greatest need of aviation.

The development of radio communication as an integral part of our commercial flying structure is the most important and the most neglected step to promoting safety in aviation. Its general adoption is not so much a matter of developing new equipment as one of convincing the aircraft industry of the value of radio.

Radio serves the aeronaut in several distinct capacities. At all important landing fields, radio stations are required for the exchange of weather reports, to report the leaving and arrival of ships, to issue orders to aircraft in flight and to disseminate periodic weather reports. With a properly coördinated system of collecting and distributing weather information, storm warnings can be issued in ample time to assure the comfort of passengers and the safety of cargo. At least 500 low-power transmitting stations for this purpose will ultimately be required, as well as a few high-power transmitters to broadcast information to these landing field stations.

Another important function of radio is to mark out the highways of the air and to keep the aviator on his course. The aircraft direction beacon, which radiates two directional signals at forty-five degrees from the prescribed course, has demonstrated its usefulness. The radiated signals consist of mechanically sent dots and dashes, so timed that, when a flier is exactly on his course, the combined signal received from both directional stations equally forms a single series of dashes. But should the pilot deviate from his course, the signal from one of the directional antennas predominates and produces a distinctive signal, enabling him to determine whether the plane is to the right or to the left of the prescribed course. At a distance of more than fifty miles, short-wave beacons become erratic in their behavior and directional readings unreliable. Therefore aircraft direction beacons should be placed in operation each one hundred miles along the principal highways of the air.

ABOARD A PRIVATE MOTOR YACHT

The motor yacht *Crusader*, owned by A. K. Macomber of California is one of the most elaborately fitted yachts afloat, from the radio point of view. The ship has elaborate broadcast receiving equipment with loud speaker outlets in nearly every cabin. The illustration shows the 0.5-kw. voice transmitter aboard the *Crusader*

A third service is the aircraft beacon or radio lighthouse which gives a distinctive signal to a ship in flight when it is within a definite distance of a given marker point. In foggy and heavy weather, the radio beacon enables the flier to come sufficiently close to the landing field that its neon light beacon can guide him to a safe landing. Literally thousands of these low-power marker beacons are required to serve as the sign posts on the highways of the air.

Recently, the Department of Commerce awarded a contract covering radio equipment for twelve radio-controlled stations, six radio beacons and twelve markers, at a total cost of slightly more than $150,000. The Assistant Secretary of Commerce for Aeronautics, William P. MacCracken, stated:

> "Radio telephone communication to the airplane is expected materially to decrease accidents and provide for stability of schedules with greater comfort to air travelers and may be considered the greatest need of air transportation to-day."

The leaders of research in the radio industry have by no means neglected the requirements of aviation. The General Electric Company and the Westinghouse Company have developed standard models of directional signal transmitters and beacon equipment. The American Telephone & Telegraph Company has recently added an airplane to its experimental equipment at Whippany in order to perfect various types of aircraft radio-communication apparatus. Receivers which give visual indication of direction have been developed.

The principal obstacle to the use of radio on aircraft arises out of the fact that radio is considered by the greater number of pilots only as an additional burden and nuisance. The airmen's opposition is singularly reminiscent of the ridicule which sea captains accorded radio when the first installations were being made on passenger ships. It required more than a decade of education to make the sailor welcome the radio operator. The aircraft pilot remembers radio as a necessary evil to his course in military flying. He complains of the radio helmet which he must wear, because it prevents him from hearing the functioning of his motors. His ear must be ever alert to observe the slightest irregularity in their functioning.

But newly developed forms of radio equipment are day by day lessening the attention required on the part of the pilot to operate the radio equipment. A recent innovation, for example, is the installation of microphones in the fire wall at the aircraft's motors so that the pilot, wearing a radio helmet, can, by the flip of a switch, choose between the radio signal or the microphone's output. The latter gives him

a better indication of the motor's functioning than any direct aural observation.

The highways of the air will become routes of commerce and travel with the establishment of low-power beacons, close together on the line of flight, directional beacons, and an aircraft communication network. Adequate radio sign posts of the air will do more to help the development of commercial aviation than foolhardy transatlantic publicity stunts, performed in the name of science, often by pilots who prefer to fly without scientific equipment.

No Innovations or Revolutions for 1928

THE June trade show in Chicago will be under way by the time these lines appear in print. Last year, the exhibit inaugurated what the public accepted as a radically new type of radio set with the effect of making the previous year's offerings quite obsolete. The hurrahs with which the alternating-current receiver was greeted upset the stability of the industry.

This year's improvements are much less radical and represent much more normal and sounder progress. Appearance and simplicity of control are becoming the outstanding factors by which the public selects its radio receivers. The most interesting developments along these lines are the new receivers shown by the Zenith Company. Instead of turning a dial to select his station, the listener now presses a button. As a practical improvement, the advantage gained is not startling, but the public, ever ready to jump at novelties, will undoubtedly greet the new receiver with an amazing show of interest.

There is a powerful undercurrent of talk aroused by the announcements regarding television and picture transmission. Having had so many experiences with premature announcements of progress, the industry is not greeting television talk with any great enthusiasm. It fears the public will develop the attitude of mind that it is worth while to defer purchasing a radio receiver so that they may have one in which a television receiver is incorporated. This development is not definitely in prospect. No one has yet made a true television device in commercially marketable form nor have we heard of any television transmitter which can be used in the broadcast band. Every one of the existing systems depends upon the building up of an entirely new short-wave broadcasting structure together with a new audience using short-wave receivers. Both the industry and the public will be greatly benefited if the television propagandists would give adequate demonstrations of the experimental apparatus they plan to market.

Our British contemporaries have found it necessary to warn their public of the danger of misleading announcements regarding television. We would welcome with open arms the development of practical television, but would regret any stagnation of radio at this time on account of its prospective development. In the hope of contributing practical information on the situation, we quote the statements on a few technical authorities which bear on the situation.—F. B. Jewett, President, Bell Telephone Laboratories, Dr. Michael I. Pupin, engineering authority and inventor of the loading coil, Dr. J. H. Dellinger, Director of the Radio Laboratory of the Bureau of Standards, Dr. Lee DeForest, inventor of the three-element tube, C. Francis Jenkins, television research engineer and inventor, David Sarnoff, Vice-President of the Radio Corporation of America, and Percy W. Harris, British technical writer.

Some of these statements follow:

F. B. JEWETT (in the New York *Times*): At the public demonstration which we made on April 7, 1927, of the results then obtained, Mr. Gifford, President of the American Telephone and Telegraph Company, stated, among other things: "The elaborateness of the equipment required by the very nature of the undertaking precludes any present possibility of television being available in homes and offices generally." Nothing which has developed as a result of our work in the past year has tended to alter this opinion of Mr. Gifford.

DR. MICHAEL I. PUPIN: I do not know when television will be practical for the home. I do not know anything about the latest improvements which have been developed by those who are directly interested in the development of this art. But as far as I do know this art has a great many complications in its operation, and I do not see clearly how these complications can be eliminated so as to make television fool-proof in operation and thus make it practical for the home.

DR. J. H. DELLINGER: There is no doubt that the development of television will go forward and that eventually television will be commercially used. It seems likely, however, that it will continue to be an expensive process, requiring complicated apparatus and careful synchronization and adjustment of high-frequency electric currents.

DR. LEE DEFOREST; Until some radically new discovery in physics is made which will simplify the present problems of television, we cannot expect to find this in the home in a practical, commercial form and at a price which even the wealthy can afford. There are so many factors to be considered besides the mere physical and electrical problems. . . . I am willing to go on record to the effect that practical, commercial, reasonably priced television equipment for the home will not be on the market within five years, and very likely not within twenty-five years.

C. FRANCIS JENKINS: Transmission by wire or radio of a baseball game from the ball field as the game progresses is unlikely to be attained short of three to five years more of research.

DAVID SARNOFF: At the present time an entirely new era of radio communication—radio television—is opening before us. We are not now manufacturing television apparatus for the home, because, frankly, we do not yet know how to make a simplified and low-priced television receiver practicable for home use. Nevertheless. I firmly believe that within the next few years such equipment and service will be developed and made available to the home.

PERCY W. HARRIS, in *Popular Wireless* (London): In common with a large number of other experimenters, I have closely watched the progress of television both in this country and abroad, and I have not the slightest hesitation in stating that in my humble opinion we have not even measurably approached the time when the home constructor, as distinguished from the skilled experimenter, can try his hand at the game. The home constructor comes into his own when the fundamental problems have been solved and when the development of a particular art is a constructional one and a question of detail. The fundamental problems of genuine television have *not* been solved either in this country or abroad, nor can I see that they are likely to be along the lines so far pursued.

RADIO BROADCAST has enthusiastically fostered and encouraged the development of equipment which will enable the amateur experimenter to familiarize himself with progress in the new art. We have been careful throughout, however, to point out that the new field is yet distinctly one of experiment, and that it is not yet a regular service to the listener. Still picture reception is a fascinating field for the experimenter and gratifying results are obtainable with home-built apparatus, but the day has not yet come when the general public may look forward to a television attachment for his set.

Progress in Television

IT WAS announced by the General Electric Company on May 11 that experimental television transmissions would be made through WGY *on Tuesday, Thursday, and Friday afternoons from 1:30 to 2:00 p. m., Eastern daylight saving time on the usual* WGY *wave-length, 379.5 meters (790 kc.). The pictures consist of 24 scanning lines, repeated 20 times a second. This transmission is a part of the experiments in charge of Dr. E. F. W. Alexanderson which have been under way for the past several years. It is probable that some other transmissions, made by Nakken, Jenkins, Baird and others will be on the air within a reasonable length of time.*

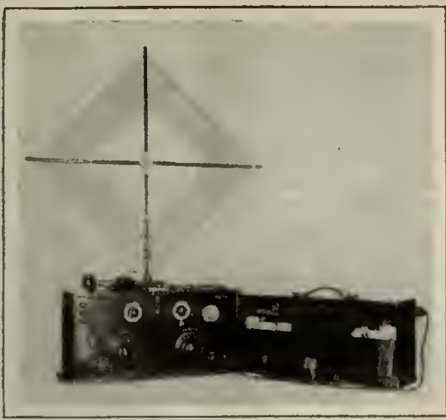
In our next issue we expect to include an article analyzing the present television systems—which are generally quite similar—telling frankly what results can be expected from each, and to include a general description of the apparatus necessary at the receiving end. As soon as there is assurance of sufficiently regular transmissions and that the apparatus for receiving television signals is available, RADIO BROADCAST *will describe its operation and assembly. A number of well-known experimenters are working on this problem now, in coöperation with* RADIO BROADCAST; *as soon as results warrant, their work will be described in these pages. The leading article this month explains some of the difficulties of television and an editorial on this page points out some pertinent facts on the subject. The reader should not forget that any television system now delivers but crude pictures and that "perfection" is not now in sight.*—THE EDITOR.

Broadcast Regulation at a Standstill

IT IS with distinct disappointment that we make reference to the broadcasting situation, which we hoped might be favorably influenced by the Davis Amendment to the Radio Act, made law by the President's signature on March 28. The amendment might have been used by the Federal Radio Commission as a means of greatly reducing the number of broadcasting stations on the air. Everything pointed to that course when the Commission announced the details of a plan, submitted by a special committee of the Institute of Radio Engineers, as a result of their exhaustive study of the capacity of the broadcast band. The plan recommended that the number of stations on the air simultaneously be reduced to three hundred and forty.

The National Association of Broadcasters, the Radio Manufacturers Association, and the Federated Trade Association raised a loud howl when the Commission's inclination to adopt this plan was indicated and, in deference to their protests, the Commission called a hearing in Washington at which these three associations, together with the N. E. M. A., presented their views.

The committee representing these three bodies offered a series of charts involving an impressive amount of long division. One set of charts worked out the power allotment to each state, based on the ratio of its population to the popu-



INTERFERENCE PREVENTION IN CANADA
Part of the license revenues received from radio listeners in Canada is used to make listening more pleasant. The Radio Service has established an interference-tracing and prevention service, with specially equipped cars to locate the trouble. The illustration shows the portable superheterodyne set which is part of the equipment of each of these cars

lation of its zone. The total zone powers computed were 137,000, 217,000, and 250,000 watts. A second chart based equalization upon the *number* of station licenses issued per zone. The zone totals offered were 110 and 140 stations, or 550 and 700 stations for the United States. The committee actually suggested increases in number of stations in most of the states of the Union and only very slight decreases in New York and a reasonable decrease in the Chicago area. It had no suggestion to offer as to how any of these figures could be applied in practice. When asked specific questions regarding the application of its plan to the actual situation, its proponents claimed they offered only a method of procedure and that any basis of total power or total number of stations might be substituted. In short, the associations disclosed how long division might be used in dividing power, number of stations, or anything which may come to mind, among the states in each zone in proportion to each state's share of its zone population. The nearest approach to a concrete suggestion offered was the advice that the Commission proceed cautiously and gradually in altering the present structure and postpone any real action as far in the future as possible.

The Federal Radio Commission has so emphatically demonstrated its lack of courage and understanding of the broadcasting problem that encouragement to continue its vacillation and its jellyfish policies is bound to be harmful. The broadcasters may be excused for seeking to protect their property interests, but the set manufacturers displayed an amazing lack of foresight, because receiving set sales certainly are curtailed by the listeners' widespread disgust with congested broadcasting conditions.

The listener, as usual inarticulate, has never, and apparently will never, present his case before the Federal Radio Commission. Radio will continue to be guided by such persons as Representative Davis, who believes that a power of 10,000 watts is the maximum that should be permitted on a clear channel. Ten thousand watts creates no less interference than 50,000 watts, yet such powers would make it impossible for rural listeners to hear the better stations at any great distance and would deprive large metropolitan areas of their principal program sources. "Furthermore," says Mr. Davis, "in spite of the statement of interested engineers to the contrary, chain programs can be successfully broadcast on the same wavelength." We wish Representative Davis were right, but simply to call qualified engineers liars does not solve the problem.

The Inequalities of "Equalization"

A FEATURE of the so-called equalization amendment which has generally escaped attention is that equalization of power by zones and state populations within zones will deprive large areas of the country of adequate radio service or else force confusion on other areas. Broadcast carriers of a given power travel certain distances regardless of whether the areas covered are highly populated or not and regardless of the geographic dimensions of the zones in which they are located. Under any method of applying "equalization," states of large area and small population must be deficient in radio service while congestion is forced upon states of large population. This is due to the ridiculous manner in which the five zones were prescribed by Congress, or rather to the error of using the zones as the basis for power allotment.

The fifth zone is approximately 1190 by 1160 miles in dimension, while the first zone is but 700 by 570. The third zone has about the same width north and south as the first, but it is three times as long from east to west. Under the equalization amendment, therefore, the South, which Representative Davis claims to protect, cannot legally have more than one third the service in broadcasting allotted to the first zone. The first zone, furthermore, is so intertwined with the second that, if the same standards of channel separation and powers which must be adhered to in order to give any kind of service to the listeners of those zones are applied to the third and fifth zones, large areas in the latter two zones must be without adequate broadcasting service.

If equalization is applied to Representative Davis's own state of Tennessee which, according to the latest figures, now has 3.3 per cent. of the nation's total broadcasting power, its total must be reduced to 1.1 per cent., *i.e.*, $33\frac{1}{3}$ per cent. of its present power. The reduction is likely to be still larger, however, because the complaints of excess power in the more progressive zones will require lower total powers per zone than the present average. Whatever the amount of power assigned to each zone under any equalization plan, according to the law, it should be divided among states according to their population. For example, California, with a population of four and a half million, will have 41 per cent. of the power of the fifth zone, while Texas, with a population of 5,487,000 will have but 19 per cent. of the total power of the third zone. Since both zones are required to have equal power, California must have double the radio service of Texas. The blatant Mr. Davis has done a wonderful job of protecting the interests of the South!

The state of Massachusetts, with a population slightly less than that of California, will have but little more than a third the power allotted to California. Porto Rico will have ten times the power of Alaska. The entire New England states will have but three fourths of the power assigned to Pennsylvania.

The suggestion is frequently made that channels be borrowed for congested areas. A free channel, available to Arizona or Oregon, cannot be loaned to New York or Pennsylvania, because that channel is presumably already occupied there. There is no surplus of cleared channels. Borrowing offers no substantial relief to mitigate the abuses of so-called equalization.

Hampered by the asinine equalization clause, the Federal Radio Commission must adopt a standard of power for each zone sufficiently high so that the large areas of the West and South can have reasonable service. This will require hopeless congestion in the first and second districts, and in the eastern part of the fourth district, which are compact geographically and have numerous large cities worthy of local service stations. The only effect of the law will be that, rather than to destroy what is left of radio, the Commission will disregard it and conditions will be made neither worse nor better than they are to-day. The hoped-for improvement of conditions, which the establishment of the Federal Radio Commission was intended to accomplish, has been made a practical impossibility through the muddling of Congress and nearly every other body involved in the problem.

Another Non-Radio Man for the Commission

WE HAVE hesitated to comment on the appointment of such an estimable gentleman as Judge Ira E. Robinson as a member of the Federal Radio Commission. Later he was unanimously elected its Chairman. We weary of complaining of the President's appointment to the Commission of men totally unfamiliar with the problem. Judge Robinson is a delightful character and adds decidedly to the social grace of the Commission. Years of legal training have vested him with what might be termed as an excess of caution, and the President may rest secure that, while the Commission is under his leadership, nothing but well-considered steps will be taken. The Judge is totally unqualified from the radio standpoint, having not the least understanding of service and heterodyne ranges, and broadcast congestion. He was confirmed by the

A TELEPHONED MOVIE FILM
Recently, the American Telephone & Telegraph Company transmitted a motion picture film between New York and Chicago. The strips of film were cut, three were placed side by side and these transmitted by "telephoto"

Senate, together with his confrères, Caldwell, LaFount and Pickard, on March 31.

What the Commission most needs is one or two commissioners who have some understanding of radio. Much time is lost in familiarizing men unacquainted with the allocation problem with its technical aspects, and each appointment hampers and delays the Commission's progress. The wisdom of appointing experts in their respective lines to regulatory bodies such as the Federal Reserve Board and the Interstate Commerce Commission has been recognized, but radio's engineering problems have been turned over largely to lawyers for solution.

The Commission Eliminates Its First Station

FOR the first time since the Government has controlled radio, the Federal Radio Commission has taken the decisive step of ordering a station off the air. The station in question is WNBA of Forest Park, Illinois, one of scores which has caused continuous complaints about frequent wabbling. It would have been fairer to apply this elimination process to all stations equally guilty with WNBA. But, being warned by this instance, it is likely that many of the radio mosquitoes will get busy and make a belated effort to comply with the Commission's regulations and thereby another means of station elimination, which does not involve the threat of court action of any serious consequences, is lost to the muddled Commission.

The Engineers' Plan of Allocation

THE engineers' plan of broadcast allocation, which has been described as being too drastic, actually represents the least possible hardship upon the broadcasting station owner. The plan provides for 10 stations of 10,000 watts power or more on full time in each zone, 9 of 500 watts on full time, 18 of 500 watts power on half time, 40 of 250 watts on half time, 60 of 250 watts power on one third time. This totals 137 stations for each zone, or a grand total of 685 for the five zones.

The High-Frequency Spectrum

THE report to the Federal Radio Commission, relative to the assignment of short-wave channels, rendered by Commander S. C. Hooper, who was assisted in its preparation by Dr. J. H. Dellinger of the radio laboratory of the Bureau of Standards, Dr. C. B. Jolliffe, and W. E. Downing, suggests that, until further progress in frequency stabilization is made, stations be assigned only to alternate channels in the short-wave spectrum. By gradually increasing the stability required over a period of years, it is hoped that room for additional stations will be found as they are required in commercial service.

On a basis of one tenth of one per cent. channel separation, the report states, there are 398 channels in the "mobile" bands. Of the 190 channels between 1500 and 4000 kilocycles, 89 are in use and 101 are available to all the countries of the world. The United States will lay claim to ten of these channels.

In the band between 4000 and 23,000 kilocycles, the number of "mobile" channels is 208, of which a hundred are now in use. That leaves 108 immediately available to all the nations of the world, of which the United States plans to utilize twenty.

In the "fixed service" bands, using alternate channels, there are 710 channels. Between 1500 and 4000 kc. are 130 fixed service channels, of which 42 are in use and 88 available. Ambitious short-wave applicants in the United States have made application for 128 channels in this band. Between 4000 and 23,000 kc. there are 508 channels of which 370 are being used. The United States is at present occupying 260 of these. For the 210 channels remaining immediately available for assignment to all the nations of the world, there are 292 American applications.

Considering that fully half the applications for short-wave channels are made by companies totally unacquainted with short-wave transmission which hope to save some money on their telegraph bills thereby, and the other half are made by communication companies which are, one suspects, bluffing in order to prevent the channels falling into the hands of their competitors, the Commission is up against another hopeless problem, totally unsuited to its uncertain and hesitant temperament.

RECENT RADIO EVENTS

THE Federal Radio Commission has granted nineteen permits to the Boeing Air Transport Company of Seattle in order that they may erect radio stations at as many landing fields, scattered from Chicago to the Pacific Coast.

THE Radio Corporation of America has applied for license to construct 65 short-wave transmitters in order to establish an overland short-wave system and to counterbalance, apparently, the applications of the Mackay interests for channels for similar purposes.

THE Radio Committee of the American Railway Association has asked for a band 144 kc. wide between 2250 and 2750 kc. for train communication. They claim that the range of train equipment is limited to about five miles and that the interference range is but ten miles. These frequencies for which they ask are wisely selected from a standpoint of creating minimum interference.

THE new 10,000 watt station KSTP, National Battery Company of St. Paul, Minn., went into operation early in April. This is now one of the most powerful stations west of Chicago.

RADIO EQUIPMENT AT THE RUGBY STATION

THE frontispiece illustration of RADIO BROADCAST for February, 1928, showed a view of the interior at one of the transmitter buildings of the Rugby radio station of the British Postoffice. The caption under the illustration suggested that it was built by the British Marconi Company for the Government. We are informed by the International Telephone and Telegraph Company that the radio telephone transmitting equipment at Rugby was provided by Standard Telephones and Cables, Ltd., one of the manufacturing companies associated with the I. T. & T. The radiophone equipment was constructed with the advice of the American Bell Telephone Laboratories who were responsible for the design of the American end of the transatlantic telephone circuit equipment now in daily use at Rocky Point, New York. The radio telegraph equipment at Rugby was designed by British Postoffice engineers and was supplied by a number of different makers. Readers who are interested will find complete descriptions of this installation in the *British Post Office Engineers' Journal* (January, 1927, E. H. Shaughnessey), and (April, 1927, Lt. Col. A. G. Lee and R. V. Hansford).

TO REVISE THE PATENT LAW

SENATOR KING is endeavoring to bring about an investigation of the present patent procedure. He points out that there are 95,000 patent applications awaiting action in the Patent Office, many from six to eight months, and it requires from two to seven years after an application is made to secure actual protection. Congress might well investigate the patent situation because our present industrial structure requires a new and different patent law, with compulsory licensing at reasonable royalties. The present patent monopoly is no longer a protection to the public because patents are grouped by such large and powerful interests that, in many fields, the independent inventor cannot profit from his discoveries unless he turns them over to existing combinations. This applies particularly in the radio industry.

RAPID WIRE PICTURE TRANSMISSION

THE Bell System broke all records for rapid transmission of a moving-picture film from Chicago to New York. The method employed was to take a moving picture of a well-known film actress, Vilma Banky, in Chicago, and to transmit the negative by wire to New York, where it was received, three sections of strip in tandem, as a regular still photograph. The film was then re-mounted in strip form in New York and reproduced within a few hours after it had been originally made in Chicago. It required two hours of transmission to send ten feet of film as still picture. This is really the first successful transmission of high-grade television. It is an illustration of how still picture photography may prove the gateway to television.

THE Canadian Government has refused to renew the broadcasting license of the International Bible Students' Association in Toronto and elsewhere. It announces that these licenses are cancelled at the request of thousands of listeners. The same group of religious propagandists is asking for one or two channels for 50,000 watt stations in the United States. Proponents of sectarian religious groups urge that, since jazz and commercial broadcasting have all the channels they want, religious stations should not be refused the opportunity of going on the air. The only fallacy of their argument is that jazz and commercial programs tend to be universal in their appeal, while any particular religious station serves only a minority of listeners within its area. It is difficult, however, to apply the principles of justice to the assignment of channels for religious interests because each sect firmly believes that, if discrimination is shown and its privileges curtailed, the Federal Radio Commission and the Government are instruments of the devil. A well-conducted broadcasting station is a profitable enterprise for any religious organization.

THE R. C. A., G. E., and Westinghouse companies have formed a new subsidiary to be known as R. C. A. Photophone, Inc. The company will market a home talking movie machine. David Sarnoff is President of the new company, Elmer Bucher, Vice-President, and Dr. Alfred N. Goldsmith, Vice-President in Charge of Technical Matters. The apparatus is especially adapted for use in schools and churches. It uses standard films without synchronized speech as well as the talking film.

FEDERAL-BRANDES, Inc., is changing its name to the Kolster Radio Corporation and is applying for the listing of its securities on the New York Stock Exchange.

—E. H. F.

A New Principle in Audio Transformer Design

By KENDALL CLOUGH

Research Laboratories of Chicago

THOSE who go to the market for audio transformers have noted, no doubt, the disparity in size of the devices that are offered. It will also be noted that, as a general rule, the physical size increases as the claims for fidelity of reproduction increase. This article proposes to explain the basic reason for these variations in physical size as well as to describe a new principle in the design of transformers. By the use of this new principle it is possible to produce the ideal audio curve, impossible with the conventional transformer, as well as eliminate a type of distortion that is present in the latter but which is not indicated by its characteristic curve no matter how good it may appear.

The circuit of Fig. 1 shows the representative stage of amplification as ordinarily used in radio sets. The signal voltage, e_g, impressed on the grid of the first tube may be of any frequency between 30 and 10,000 cycles corresponding to the range of frequencies concerned in the reproduction of speech and music.

The tube on which the voltage, e_g., is impressed has an amplification factor of μ, and a plate resistance, r_p. In the plate circuit of the tube we have connected a transformer having an inductance, L_1, and the turns ratio, N. Consider that the secondary operates into an infinite impedance, an assumption that is justified when the transformer operates into a tube with sufficient C bias. We will modify this assumption later for the high frequencies.

In such a circuit as this, the amplification may be expressed by the equation:

$$A = \frac{e_2}{e_g} = \frac{\mu N}{\sqrt{\left(\frac{r_p}{\omega L_1}\right)^2 + 1}} \quad \textit{where} \quad \begin{aligned} A &= \text{amplification} \\ \omega &= 2\pi f \\ L_1 &= \text{primary inductance} \end{aligned}$$

This equation first defines amplification as the ratio of the voltage impressed on the second grid circuit to the voltage impressed on the first grid circuit. We note that the amplification is directly proportional to the amplification factor of the tube and the turns ratio of the transformer. This might lead one to believe that almost any degree of amplification could be accomplished by the use of a high-mu tube and a high ratio transformer. This is not the case.

Using a transformer having a primary inductance of 44.2 henries and a turns ratio of three, we have, by use of the above equation, plotted in Curve 2, Fig. 2, which shows the amplification at various frequencies when used with a tube having an amplification constant of 8 and a plate resistance of 10,000 ohms. This corresponds approximately to a 201-A tube. It will be noted that the curve is not ideal by any means, for at 30 cycles (the lower limit of the frequencies we are concerned with for the reproduction of music) the amplification has fallen off to 15.5 while

THE author of this article is no stranger to RADIO BROADCAST'S *readers. He has designed several of the popular receivers we have described, and is well known as an excellent radio engineer. In this article he discloses for the first time his new audio amplifying system on which he has been at work for some time. The advantages of this system are several. It provides an amplifier that is flat from 30 cycles to above 6000, or, if desired, a rising characteristic between 30 and 100 cycles. This is done at less cost than that of a conventional transformer-coupled amplifier, and with somewhat greater voltage gain. At the same time the introduction of harmonic frequencies in the output due to saturation of the core of audio transformers due to the d.c. plate current which flows through them, is avoided. Although we have not seen the data, we understand that a study of this effect at Cruft Laboratory proved that at times the third harmonic in the output of an amplifier in which d.c. flows through iron cores rises as high as 30 per cent. and that no adjustment of bias or plate voltage would eliminate it. Mr. Clough's system prevents such distortion. He is at work upon another article which we hope to present soon.*

—THE EDITOR.

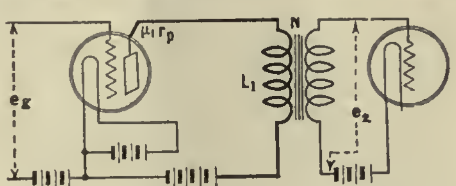


FIG. 1

the amplification at the high frequencies is 25.0. Now as was suggested, we might believe that we could secure a higher amplification such as is shown in Curve 3, Fig. 2, using a tube having a higher amplification factor, such as 30. Such a curve could be secured if we had a tube with an amplification factor of 30 and plate resistance of 10,000 ohms. This would be a very difficult tube to design and produce, however, and we see by reference to a tube chart that the 240 type (μ = 30) has a plate resistance of 150,000 ohms. Thus we can compute such a curve as is shown in Curve 4, Fig. 2, using the same transformer as was used in Fig. 2 and the new value of plate resistance, i.e. 150,000 ohms. We see in Curve 4, Fig. 2, while the amplification has been improved at the high frequencies, the amplification of the lows is very poor indeed.

The nature of the equation above indicates that we could improve the amplification of the bass notes shown in Curve 4, Fig. 2, by an increase in the primary inductance say to 672 henries. All of this seems very simple but there is a practical aspect worthy of our consideration.

BETTER RESPONSE WITH INCREASED PRIMARY INDUCTANCE?

IN MAKING the latter transformer we would require many more primary turns than we did on the 44.2 henry design, in fact about 3.9 times as many. In addition, to keep the ratio 3:1 we would need 3.9 times as many secondary turns. We assumed that the secondary operated into an open circuit. Now, if we attempted to build the transformer with a primary inductance of 672 henries we would find that the secondary turns would have a large self-capacity and that at the higher frequencies we could no longer assume operation into an open circuit because the self-capacity would practically short-circuit the secondary causing the curve to slump off as is shown in Curve 5, Fig. 2. This drop in amplification at the higher frequencies is not noticeable to the ear so long as the frequencies below 4000 or 5000 cycles are not materially impaired. But we see that Curve 5, Fig. 2, begins to drop badly at 1000 cycles so that the actual transformer fails to approach the ideal at either the high or the low frequencies. This is the reason why a transformer for the 240 tube has never appeared on the market.

Referring to the data that was used to prepare the Curve 2, Fig. 2, we might consider the possibility of producing a transformer which would have a high turns ratio in order to raise the amplification. Thus let us assume that we desire a transformer of 5:1 ratio. This would necessitate increasing the number of secondary turns by the ratio of 5:3 which would cause the amplification curve to appear theoretically as in Curve 6, Fig. 2.

However, in attempting this, we find that when the transformer is actually measured the curve would drop off at the higher frequencies as shown in Curve 5, Fig. 2, due to the fact that the secondary distributed capacity would reduce the secondary voltage at the high frequencies in the same manner as was shown in connection with the curves on the 240 tube. Practical experience indicates that a transformer with the degree of bass amplification shown in Curve 5, Fig. 2 cannot be built at ratios in excess of 4:1 without impairing the high frequencies more than the average ear will allow.

Refer to Curve 2, Fig. 2. Let us consider what

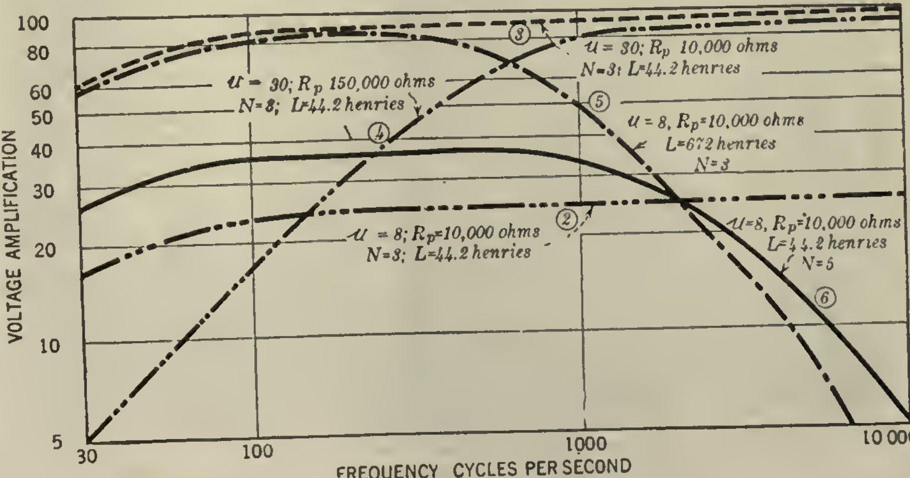


FIG. 2

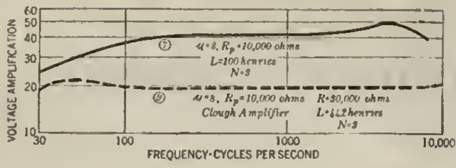


FIG. 3

can be done with the same design in the way of approaching perfection of the bass response. Using the same tube constants as were used for Curve 2, Fig. 2 and increasing the primary inductance we could plot curves for increasing values of inductance. It is plain that the bass response improves as we increase the primary inductance. Here again we run into the difficulty of secondary capacity for with each increase in the primary inductance we would have to put more turns on both the primary and the secondary. In practice we would find that after the primary had been brought to a value of about 100 henries, we could not increase it further without either decreasing the turns ratio or putting up with the deleterious effects of secondary capacity. Curve 7, Fig. 3, shows a measured characteristic of a commercial 3:1 transformer which represents about the limit along this line of procedure without reducing the turns ratio. It will be noted that in this case the amplification is yet not ideal at 30 cycles, while the self-capacity of the secondary starts to impair the amplification at 8000 cycles.

Under some conditions it is desirable that the amplification from 100 cycles, or thereabouts, down to 30 cycles should be greater than that on the flat portion to compensate losses in other parts of the circuit, the loud speaker, for example. In reproduction of phonograph records we could compensate the fact that the records are not cut up to full volume from 30 to 100 cycles, due to practical difficulties in record-cutting. By means of a new transformer circuit, an amplifier *can* be produced with either the ideal flat curve or a rising bass characteristic.

WHAT THE NEW CIRCUIT IS

THE circuit is shown in Fig. 4. Note that the plate current of the tube is carried by a resistor, R, and a condenser, C, connects to the primary. In this way the primary of the transformer carries no direct current, a feature of importance.

The equation for this form of amplification involves a resonance which may be controlled or placed, by proper design, in any part of the frequency band. Naturally, the most desirable place for this resonance is in the bass frequencies. When the amplification is computed for this system, using the same transformer and tube which was used in the illustration, Curve 2, fig. 2, together with a resistance R = 30,000 ohms, the resultant curve is as shown in Curve 9, Fig. 3, it will be seen that this curve approaches the ideal very closely and with the same amount of material as in the designs illustrated by Curve 2, Fig. 2. Here the amplification is lower than was previously obtained with the same transformer, but this condition can be corrected by connecting the transformer as shown in Fig. 5. This

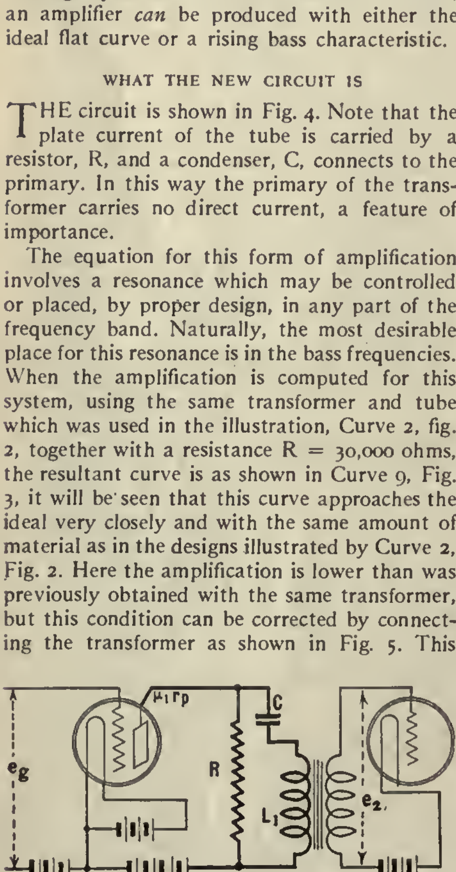


FIG. 4

auto-transformer connection increases the effective ratio to 4:1, using the same amount of copper windings that we have considered for a 3:1 ratio in ordinary transformer connections. The curve by this connection is shown in Fig. 6, Curve 11, where the amplification in the high-frequency portion is the same as we obtained with the same core and windings that were used in Curve 2, Fig. 2. The amplification at 30 cycles has been brought up to a par with the high-frequency amplification while using a transformer having a primary inductance of only 44.2 henries which may be compared with Curve 7, Fig. 3, which shows 27 per cent. decrease at 30 cycles in spite of the fact that it has a primary inductance of 100 henries. It is apparent that having a method of producing an ideal curve with a lower value of primary inductance than was necessary with the ordinary transformer connection to produce only approximately an ideal curve, we will need less secondary turns on a core of smaller cross-section. This mitigates largely the limitations caused by the secondary distributed capacity so that it is perfectly feas-

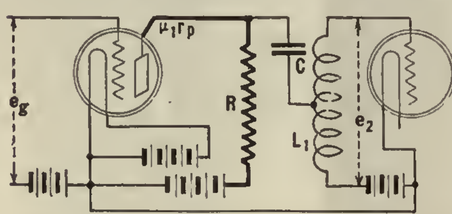


FIG. 5

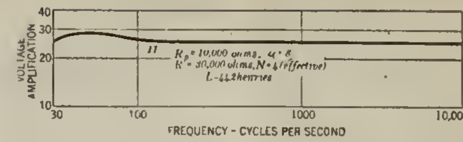
ible, where large amplifications are needed, to extend the ratio of the transformer greatly by the addition of secondary turns.

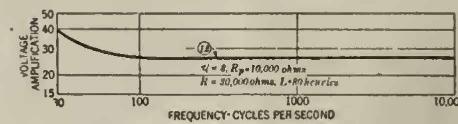
It was previously mentioned that in the event we need amplification of the low frequencies more than the highs that it could be done by means of this transformer circuit. In order to illustrate this system as well as possible, the value of the primary inductance, 44.2 henries, was chosen in order to satisfy the conditions for a flat characteristic with the particular circuit constants used. This value of inductance is prescribed by the mathematics of the circuit and the equation for the new transformer indicates that if a value in excess of this is used in design that a rising bass characteristic may be produced. Thus let us assume that the primary (in Fig. 5,) is wound to an inductance of 80 henries. The circuit would then produce a characteristic such as is shown in Curve 12, Fig. 7.

FINE RESPONSE CURVE

WHILE several makes of this device will be on the market during the coming season, it may be interesting to the reader to see what can be accomplished in the way of faithful reproduction by means of measured curves on experimental laboratory designs. The solid Curve 13, Fig. 8, shows a transformer winding of a 3:1 ratio when operated out of a 226 tube with the customary voltages and with the conventional transformer connection. The solid line Curve 14, Fig. 8, shows the same transformer operated as shown in Fig. 5 with the same tube. It will be noted that this design provides reinforcement of the low frequencies and a slight reinforcement at the high frequencies in the vicinity of the cut off. Reducing the size of the windings produces the ideal curve rather than over accentuation of the bass frequencies as shown.

A second illustration is shown in Curve 15, Fig. 9. This dotted curve was taken using a small 4:1 transformer in the usual connection; the full line, Curve 16, Fig. 9, with a transformer with



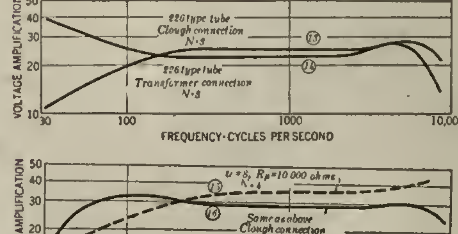


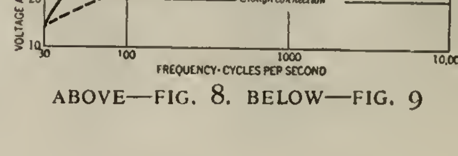
ABOVE—FIG. 6. BELOW—FIG. 7

the new connection. This curve does not go to 30 cycles, but many feel this low limit is not entirely necessary, in view of loud speakers and radio transmission shortcomings in the lowest octave of the musical register. The real point in the above curve is in its extreme departure from the ideal curve when operated in the usual connection, while with the new circuit, the curve resulting from proper design can be carried substantially flat down to any preassigned frequency.

It has, no doubt, occurred to the reader that due to the drop in d.c. potential through the resistance, R, of Fig. 4, that it will be necessary to use a battery supply of greater voltage on the detector and first-stage amplifier tubes than is usual to supply the rated plate potential on the tube. This is no serious limitation of the design, because the detector is usually operated on 45 volts and the first audio stage at 90 volts while 180 volts are usually available from the B-power supply. In all the illustrations both resistors will permit operation on 180 volts and yet operate the plates of the tubes at their rated voltages. By supplying both stages from the 180-volt tap of the power unit, we save the voltage-divider necessary for B voltages of 45 and 90, as well as saving the by-pass condensers usually necessary across these taps. Such models have been prepared in the laboratory for operation with the a.c. tubes, producing an effective transformation ratio of 5:1 in the first stage and 4:1 in the second as against values of 3:1 and 4:1 respectively, which have been found to be the practical limit for a high grade audio-amplifier using the conventional circuit.

This amplifier then has the following advantages: high quality reproduction, due to its flat characteristics from the very low frequencies to above 5000 cycles, secured at a lower cost than is now possible with standard transformer connections. This is because of the new scheme of connecting the apparatus in the circuit. There is one additional advantage which has not been mentioned here, but which is important. In any transformer in whose primary direct current flows, there is liable to be distortion introduced due to core saturation. Since there is no d.c. in this method of connecting the transformer into the circuit, such distortion cannot result. The writer hopes to present more of this side of his development later.





ABOVE—FIG. 8. BELOW—FIG. 9

No. 1 Radio Broadcast's Home Study Sheets July, 1928

The Nature of Radio and Electricity

THERE can be little doubt that radio is one of the most attractive fields for home experiment that has ever presented itself. Radio problems are not to be solved in a day; the apparatus required for intelligent experiment is not too complicated or expensive for the layman, the interesting theories involved may be mastered by anyone who cares to study; and the ramifications of radio experiment deal not only with electricity but, for example, with chemistry and acoustics as well, so the tired feeling of having solved all, is never to be experienced.

Radio is closely allied to electricity, that more or less intangible force which our senses normally refuse to recognize. We cannot see it, or hear it, and are not aware of its presence unless it is in motion, doing work of some kind. And yet it is always present ready for action, to be generated and controlled by man, and at his will to spend its energy doing useful work.

The radio experimenter plays with this force, and thereby finds out for himself many of the facts about the force that runs our street cars, lights our homes, transmits our messages, brings music out of the silent ether, and does innumerable small tasks that are no longer considered remarkable. To find out the most important facts about electricity and radio, one must experiment, not in a hit or miss fashion but with some object; he must have a good knowledge of the tools with which he works, and a clear picture of what happens when he uses those tools.

While it must be acknowledged that many inventions and discoveries have been made by individuals who work in attics and cellars without adequate mental or electrical equipment, by far the greater part of real advancement comes from research that is intelligently planned and systematically carried out.

The Laboratory Staff has planned a number of experiments which shall be described each month in Radio Broadcast, experiments which shall first be performed in the Laboratory of this magazine and which the home experimenter may repeat if he desires. These experiments deal with electricity and radio and should give the experimenter a wide knowledge and experience in radio matters.

The apparatus needed for each experiment will be given in exact detail so that the experimenter can build or buy it if he desires; the exact procedure of the experiment will be followed by the results obtained, and by a series of questions or problems or suggestions for further experiment. These questions and problems are for the experimenter to answer. If he desires to send the answers he has worked out to the Laboratory Staff, they will be glad to look them over and will always be interested to know how to make the experiments more helpful.

These pages are so prepared that it will not be necessary for the interested reader to repeat the experiments; but if apparatus is at hand, or if he desires to equip himself with sufficient instruments so that he too can take part in the great business of radio experiment, he will do well to carry out the procedure, or to amplify it at his leisure.

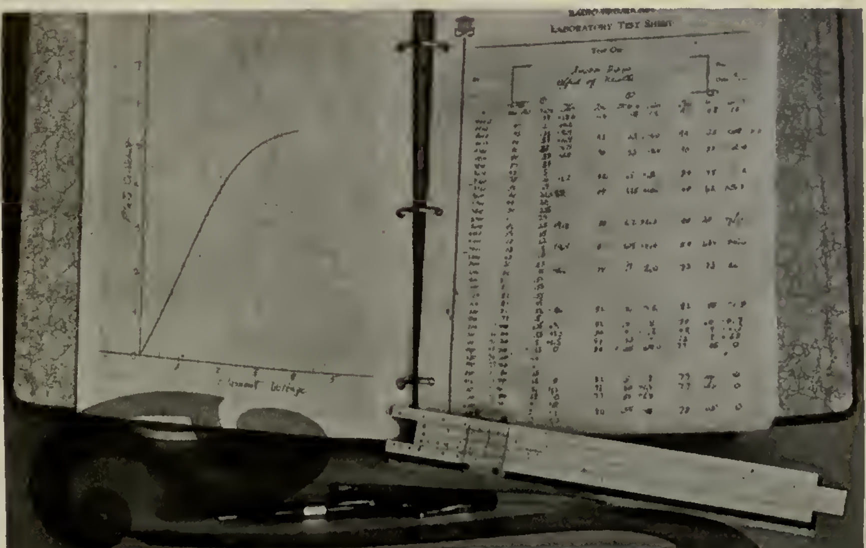
It is possible of course to carry out the calculations of many experiments without actually doing them physically at a patent saving. In fact, it will always be wise to check over the data given in these pages, working out what mathematics may appear so that almost the same effect is secured as if the actual experiment had been repeated.

The experimenter will need, first of all, a loose-leaf note book. Those used in the Laboratory are McM (Manhattan Stationery) ring books No. 518D. The actual make is not important so long as it is large enough to hold sheets the size of Radio Broadcast's pages. In this notebook should go these pages in Radio Broadcast which are marked on the margin ready for punching—there will be no excuse for having an incomplete file of experiments! There will be needed, in addition to the binder and these sheets from the magazine, a stock of paper to fit the binder, both blank and cross section. A good cross section paper is Keuffel and Esser No. N355-2R. It costs two cents a sheet and may be obtained from Keuffel and Esser, 127 Fulton Street, New York City. Another requisite is a good ruler, preferably a triangular scale graduated in 10, 20, etc. parts to the inch. Keuffel and Esser No. 8883 is a good one. One or more "French curves" are useful in making complicated graphs.

If the experimenter feels that he can afford a slide rule, he should invest in this extraordinarily useful instrument. It is a device which simplifies computations involving multiplication, division, percentages, squaring or cubing or extracting the square or cube roots, or using logarithms. With it one can save hours of time and bother and exasperation. The one used in the Laboratory is a Keuffel and Esser No. 4053-3 costing about $8. A booklet comes with it showing exactly how to use it. Of course the calculations which a slide rule—a "slip stick" as the engineer calls it—make simple may be done with pencil and paper and—when the problem in hand requires their use—with the aid of a book of logarithms. This roundabout method requires ten times the labor.

The experimenter should have a supply of pencils, pens, India ink, scrap paper, as well as a good place to work. Mathematical calculations may be carried out anywhere, so that the reader may follow this part of the experiments which will follow at his convenience. To do the actual experiments, however, in case the experiments are to be duplicated by the reader, a good light place is desirable where apparatus will not be disturbed by the domestic broom or dust cloth! A corner of the basement, the den, or attic may be used. Even the kitchen may be impressed into service with the disadvantage that the experimenter probably may have to pack up his apparatus each evening.

A good way to keep your own notebook is to work out the problems or repeat the experiment on a loose-leaf sheet which is inserted directly after that clipped from the magazine. If sent to the Laboratory for checking, the problems must be on a standard punched sheet to enable us to examine them with the least difficulty and so that the experimenter can place them in the notebook when they are returned.



Some Useful Tools for the Home Experimenter

Determining the Capacity and Inductance of a Radio Circuit

COILS and condensers are the foundation on which every radio circuit is erected. The coils possess an electrical quantity known as Inductance, and as every radio experimenter knows, the quantity that makes a condenser useful is its Capacity for storing electricity. When a current flows through the coil, lines of force surround it; the sum total of these lines is known as an electromagnetic field. The word *magnetic* is important here, for a compass—which normally points one end of its swinging needle toward the earth's north magnetic pole—will be deflected when brought near such a coil. When a current flows through a condenser, lines of force surround it. The total of these lines is known as the electrostatic field. It can be detected, not by a compass needle or any other device using the magnetic principle, but by a *charged* body such as a small bit of paper which had been rubbed on the sleeve.

The unit of capacity is the farad, named after Michael Faraday, a distinguished English experimenter. In radio circuits, however, the millionth of a farad, a microfarad, is ordinarily the quantity dealt with, or even the micro-microfarad, the million-millionth of a farad. The unit of inductance is the henry, named from Joseph Henry, a famous American experimenter. In radio circuits the unit dealt with is the milli- or microhenry, thousandths or millionths of henries. The table on this page shows how to convert farads and henries to microfarads or milli- or microhenries. For example, to change henries to millihenries, you multiply by one thousand. To convert mmfd. to mfd. you divide by one thousand; and so on.

It is the size of the coil and the condenser that controls the wavelength or frequency to which a circuit tunes. The designer of the world's best receiver must know within very close limits what the inductance of his coils must be; he knows how large a capacity he must have to cover a certain band of frequencies. It is always important to know the exact value of these two electrical quantities, capacity and inductance. The following experiment will enable anyone to find out the capacity of a condenser, and the inductance of a coil.

APPARATUS REQUIRED

1. A coil of wire. The dimensions of the coil used in the Laboratory are given in Fig. 1.
2. A variable condenser fitted with a dial. About 500 mmfd. is the best size of condenser.
3. A radio receiver, preferably with an oscillating detector; or a tube wavemeter.

PROCEDURE

1. Connect the coil and condenser across each other and bring the coil near the coil in the receiver or that of the tube wavemeter.
2. Tune the receiver to a known station near the center of the broadcast band, or if a wavemeter is used, set its wavelength to about 300 meters.
3. Change the setting of the variable condenser across the coil whose inductance is unknown, until resonance with the receiver is indicated by a decrease in signal strength, or by a click if the oscillating detector is used, or by a dip in the indicating needle of the tube wavemeter. A good meter is the modulated oscillator in the June, 1927, RADIO BROADCAST.
4. Tune the receiver, or wavemeter, to other wavelengths above and below the first medium wavelength setting until the whole of the condenser has been used, at each wavelength noting down the data as is shown in Table 1.
5. Compute the inductance of the coil from the following formula—which is one used by Professor Hazeltine.

$$\text{Inductance in Microhenries} = \frac{0.2 \times d^2 \times N^2}{3\,d + 9\,b}$$

where d is the diameter of the coil in inches
N is the number of turns of wire
b is the length of the winding in inches

As an example below is the manner in which the inductance of the coil illustrated in Fig. 1 is calculated.

$$\text{Inductance} = \frac{0.2 \times 3.06^2 \times 64^2}{3 \times 3.06 + 9 \times 1.875} = \frac{.2 \times 38400}{9.18 + 16.85} = \frac{7680}{26.03} = 292\,\mu\text{h}$$

6. Compute the capacity of the condenser at each of several of the long wavelength settings from the formula

$$\text{wavelength} = 1884 \sqrt{L \times C}$$

where L is the inductance in microhenries
C is the capacity in microfarads

For example, the 292-microhenry inductance tuned to 527 meters at 55° on the condenser dial. What is the capacity of the condenser at that point? To simplify the problem let us change the above formula to read

$$(\text{wavelength})^2 = 3.54 \times 10^6 \times L \times C$$

$$527^2 = 3.54 \times 10^6 \times 292 \times C$$

$$C = \frac{527^2}{3.54 \times 10^6 \times 292} = 270 \text{ mmfd.}$$

To provide additional examples, the capacity column in the data Table 1 has been left blank.

7. Plot this data as shown in Fig. 1
8. Make a tap at the center of the coil and repeat the above calculations and experiment.
9. Pick out some condenser setting on each set of calculations, say 60 degrees, and see how nearly the calculated capacities check.

DISCUSSION

IN THE experiment we have demonstrated the phenomenon known as resonance; that is, a circuit composed of inductance and capacity absorbing energy from another also composed of inductance and capacity, to which it is properly tuned. We have calculated the inductance of a coil by means of a formula which will give us a result accurate to within two or three per cent., provided, *a.* we measure the dimensions of the coil accurately; *b.* we make no mistake in our arithmetic, and *c.* provided the length and diameter of the coil are not too different in dimensions. The formula will be most accurate when the length of winding equals the diameter of the coil.

We have demonstrated that knowing the wavelength to which a coil-condenser combination tunes, and knowing the inductance, we may calculate the capacity. This is one means of calibrating a condenser, that is, determining the relation between dial degrees or divisions and microfarads of capacity. The accuracy with which we determine the capacity by this method is none too great, but for all practical purposes it is good enough provided, *a.* we make no error in our arithmetic; *b.* we know the wavelength accurately; *c.* we can set the condenser dial accurately to the wavelength of the receiver or wavemeter, and *d.* the capacities being measured are fairly large, say 250 mmfd. and more. This latter proviso is because the actual capacity across the coil is made up not only of the capacity of the condenser but of the leads connecting coil and condenser and the distributed capacity of the coil. This latter capacity is a bothersome factor in all experimenters' calculations and experiments. It is discussed in the Signal Corps book, *Principles Underlying Radio Communication*, page 244, in the *Bureau of Standards Bulletin* 74 on pages 137–8 and in Morecroft's *Principles of Radio Communication*, page 230–235.

The capacity of the condenser used in the Laboratory, a General Radio "tin can" Type 247E, was actually 300 mmfd. at 55° while our calculations showed it to be 270 mmfd.—an accuracy of 10 per cent. The coil as measured on a bridge had an inductance of 280 microhenries instead of 292 as calculated—an accuracy of 95.6 per cent.

TABLE 1

condenser setting in degrees	*condenser capacity in mmfd. (calculated)*	*wavelength in meters*	*frequency in kilocycles*	*(wavelength)²*
78.5	270	621	483	385,000
55.0		527	568	277,000
41.0		458	655	210,000
32.0		408	735	166,600
26.5		370	810	133,700
22.0		338	888	114,000

TABLE 2

Name of unit	*abbreviation*
farad	f.
microfarad	mfd.
micromicrofarad	mmfd.
henry	h.
millihenry	mh.
microhenry	µh.

TABLE 3

f.	= one million	mfd.	$= 10^6$ mfd.
f.	= one million million	mmfd.	$= 10^{12}$ mmfd.
mfd.	= one million	mmfd.	$= 10^6$ mmfd.
mfd.	= one millionth	f.	$= 10^{-6}$ f.
mmfd.	= one millionth	mfd.	$= 10^{-6}$ mfd.
mmfd.	= one million millionth	f.	$= 10^{-12}$ f.
h.	= one thousand	mh.	$= 10^3$ mh.
h.	= one million	µh.	$= 10^6$ µh.
mh.	= one thousand	µh.	$= 10^3$ µh.
mh.	= one thousandth	h.	$= 10^{-3}$ h.
µh.	= one thousandth	mh.	$= 10^{-3}$ mh.
µh.	= one millionth	h.	$= 10^{-6}$ h.

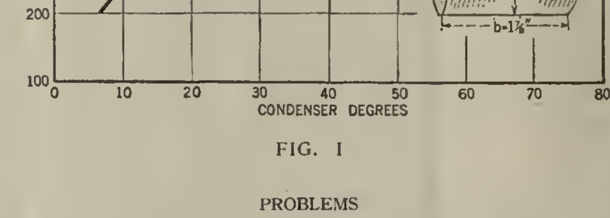


FIG. 1

PROBLEMS

1. Calculate the inductance of two coils which have the same diameter and length of winding, but of which one has twice as many turns as the other, obtained by using smaller wire.
2. The coil used in the Laboratory was too large to cover the broadcast band effectively with a 500-mmfd. condenser. Half the number of turns is too few. What is the correct number of turns, providing the diameter and length of winding is the same?
3. With a condenser whose maximum capacity is 150 mmfd. what is the coil inductance required to tune to 40 meters, 80 meters?
4. How many microhenries is 0.370 millihenries?
5. How many microfarads is 500 mmfd.?
6. If the minimum wavelength a broadcast receiver can be tuned to is 240 meters, and if the condenser has a minimum capacity of 5 mmfd. and at 500 mmfd. the receiver tunes to 600 meters, what is wrong? Why will not the receiver tune to shorter waves?

Making an A-Power Unit From Your Battery-Charger

By ROBERT BURNHAM

THERE are probably many among our readers who have a source of 110-volt a.c. and who are still hesitating to supply the filaments of their tubes directly or indirectly with a.c. We described in recent issues the ease with which the adaptor kits with cable and attendant filament transformer may be used to avoid the A-battery. Now, the faithful battery-charger occupies a new place and the present article by Mr. Burnham describes how a very serviceable A-supply may be constructed. A power unit was constructed in the Laboratory in accordance with the data given in this article. We used a Tungar 2-ampere charger in conjunction with A-filter condensers and the proper chokes. With this form of filament supply for a standard storage battery set, the hum audible in a high-quality loud speaker was quite low.

—The Editor.

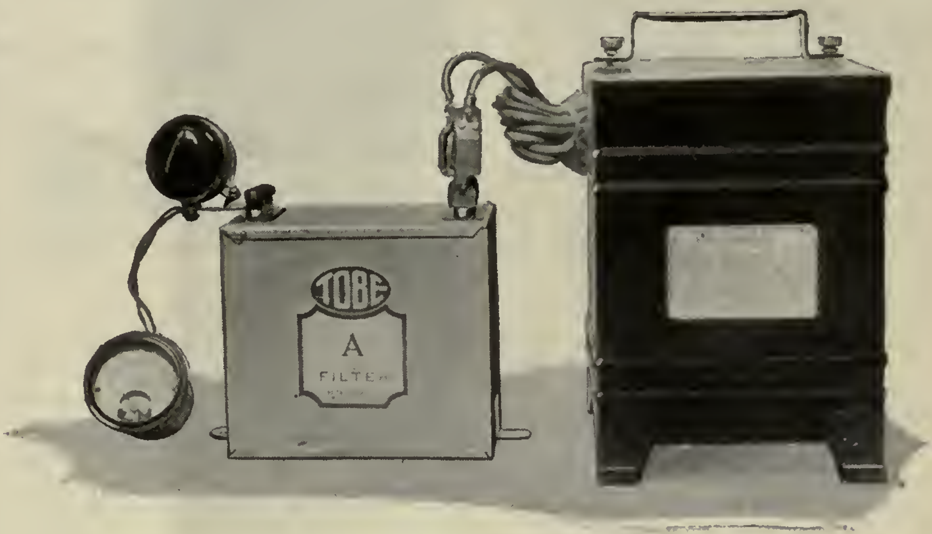


FIG. 1. HOW TO ASSEMBLE AN A-POWER UNIT AT HOME

A battery-charger, an A-filter, a rheostat, and a voltmeter are combined to produce a source of filament current directly from the light socket. In this illustration we show the use of a complete Tobe A-filter consisting of choke coils and condensers, all combined in a single container; the input terminal of the filter connect to any good battery-charger of not less than 2-ampere rating and the output of filter goes through a 10-ohm power rheostat to the filament terminals in the radio receiver. The voltmeter reads the output voltage which should be adjusted to 6 volts. A unit such as this can supply up to 8 or 10 201-A tubes or their equivalent, and makes it possible to do away with the storage battery, and obtain complete a.c. operation of the radio receiver

THE owner of a battery-operated radio receiver who desires to convert it to a light-socket operation has before him a definite problem. How shall the conversion be accomplished? To many, converting a receiver to light-socket operation means only revising the set for the use of a.c. tubes. This is one way to do it. Another method of making a set light-socket operated, which in some cases may prove cheaper and easier, is illustrated in this article.

In the first place we should realize that the part of the power equipment of a radio receiver which in most cases makes the set *not* light-socket operated is the storage battery. The B and C potentials for the set are now generally supplied from the light socket through the use of a B-power unit. Therefore, any device which enables us to obtain filament current from the power mains without the use of a storage battery, supplies the missing link in the a.c. chain. It should he realized that "light-socket operated" does not necessarily imply the use of a.c. tubes; any method whereby a receiver is operated with power from the light socket is a method of socket-power operation no matter what types of tubes are used in the set.

THIS A-POWER CIRCUIT IS SIMPLE

THE method used in B-power units to obtain B and C potentials from the light socket is quite familiar to our readers. For these potentials we take the current from the light socket, rectify it, filter it and then apply it to the radio receiver. It seems reasonable to suppose that the same method might apply equally well for the A supply. So it can, and the various A-power units now on the market make use of a rectifier-filter system to deliver sufficient current at six volts for the operation of radio receivers containing up to about 8 or 10 storage battery tubes.

An A-power unit consists, as we have mentioned above, of a rectifier and a filter system. The rectifier may be any of the types ordinarily used in battery chargers capable of supplying enough current (about 2 amperes) and the filter system should consist of a combination of a choke coil and two special condensers designed for use in A-power units and containing a large amount of capacity—several thousand microfarads. Condensers for use in A-power units are now available as are the choke coils and it follows therefore that by making use of these two units any owner of a battery charger can make himself an A-power unit. The storage battery can be discarded and your present radio receiver—with no other changes—in the future operated directly from the light socket. This is the particular subject of this article—how to make an A-power unit using your battery charger. Thus the millions of battery-chargers in use around the country can be used with an A-filter to give the owner of the receiver a.c. operation requiring no rewiring, harnesses, or new tubes. Certainly this is worth considering.

The essential parts required are the battery-charger and A-filter, a power rheostat to control the output voltage of the unit, and a voltmeter to read the output voltage. Most of the companies making these various parts are listed in the table accompanying this article.

The story of how to do it is told quite completely in the illustrations accompanying this

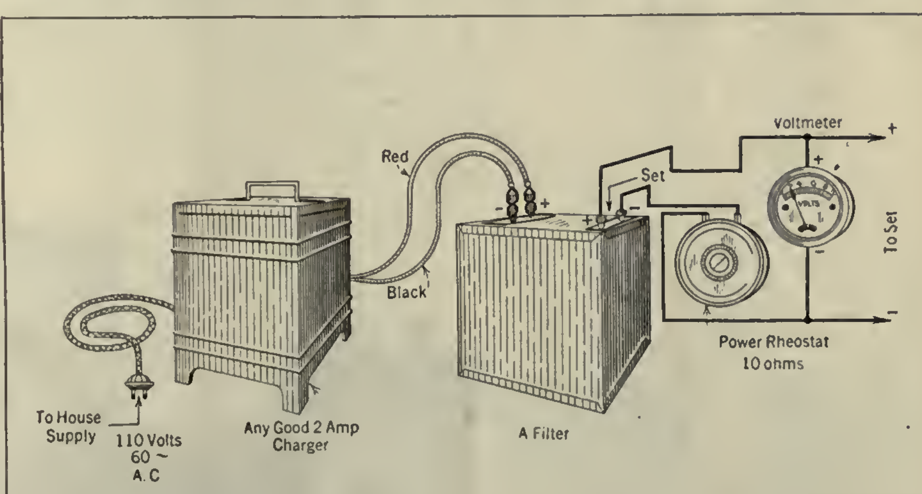


FIG. 2. HOW THE PARTS SHOULD BE CONNECTED

This picture-diagram shows clearly how the units are wired. The various parts can all be mounted on a single baseboard and then located at some point convenient to the radio receiver. Be sure to use a power rheostat, for ordinary types will not safely carry enough current. With the receiver turned on, adjust the power rheostat so that the voltmeter reads six volts. If the line voltage varies it may be necessary to readjust the rheostat in the course of an evening

Where to Get the Parts

A-CONDENSERS	CHOKE COILS	COMPLETE A-FILTERS	10-VOLT VOLTMETERS	RHEOSTATS
Aerovox Wireless Corp.	American Transformer Company	Tobe Deutschmann Company	Burton-Rogers	Carter
Dubilier Condenser & Radio Corp.			Jewell	Centralab
				Clarostat
Elkon Works, Inc.	Knapp Electric Company	Knapp Electric Company	Sterling	Frost
				Ward Leonard
Tobe Deutschmann Company			Weston	Yaxley

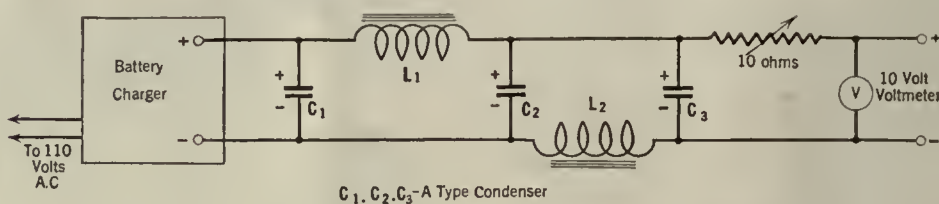


FIG. 3

The circuit of an A-power unit. The filter circuit for an A-power unit made from a battery-charger consists of two choke coils and three A-type condensers arranged as indicated in this circuit diagram. Note that one of the chokes is connected in the positive lead and the other in the negative lead. These A-condensers, unlike ordinary condensers such as are used in B-power units, have a definite polarity and the red lead or the terminal marked *plus* must always be connected to the positive side of the circuit. The choke coils should have an inductance of about one quarter of a henry and should be able to carry about 2 amperes of current. The 10-ohm rheostat regulates the output voltage. The entire filter circuit may be easily laid out on a wooden baseboard or arranged in more compact form to suit local conditions. Manufacturers making the various parts that can be used are listed in the table accompanying the article

article. Those who buy the Tobe A-filter need only connect it between the battery-charger and the A-terminals of the receiver and the job is done; those that want to make up their own filter circuit need to get a choke coil and two A-condensers. The completed unit will be as fool-proof as it is possible for any power unit to be. [Those receivers which make use of a rheostat in the r.f. filament circuit to control the volume may find the means of superseding the storage battery suggested in this article of some disadvantage. The regulation of the system is quite poor (a characteristic of all A-power units, as far as we know) and when the volume is lowered by decreasing the filament current to the r.f. tubes, the other tubes in the receiver will be supplied with excessive filament voltage. In such cases it will be better to change over to some other type of volume control which does not function by varying the filament voltage. Several methods of alternative volume control were discussed in "New Apparatus" in our June number—*Editor*.] These condensers require no attention—they are dry and may be operated in any position. Don't try to use these condensers in B-power circuits, in circuits where there is a.c., or in circuits in which the voltage exceeds about 10 volts d.c. The condensers have been designed for use only in low voltage d.c. circuits, such as are found in A-power circuits.

THE BEST FILTER SYSTEM

THE arrangement of the filter system which will prove best is shown in the illustration Fig. 3. The condensers, C_1, C_2, and C_3, are A type condensers and the chokes, L_1 and L_2, are rated at about 2 amperes and 0.25 henries. The condenser, C_3, is not always necessary, but if the audio amplifier in the receiver is a very good one, giving good gain at low frequencies, it may be necessary to include the third condenser, C_3, in Fig. 3. On most commercial receivers with audio amplifiers of indifferent quality the third condenser is not required; good home-constructed receivers generally require the use of the third condenser. In arranging the apparatus, the two choke coils should be placed with their cores at right angles to each other.

To control the output of the unit it is necessary to use a heavy duty rheostat with a value of about 10 ohms. [A 10-ohm rheostat may not prove satisfactory if the receiver contains only two or three tubes. A 15-ohm rheostat is more satisfactory in such cases.—*Editor*.] Manufacturers of satisfactory rheostats will be found listed in the table accompanying this article. It is also wise to include a voltmeter (range 0–10 volts) in the installation so that the rheostat may be accurately adjusted to the point where the correct voltage is applied to the receiver. This voltmeter will also serve to indicate when the line voltage varies and the rheostat can then be adjusted to compensate the variation in line voltage. How the rheostat and the voltmeter are connected in the circuit is shown in the diagram Fig. 3.

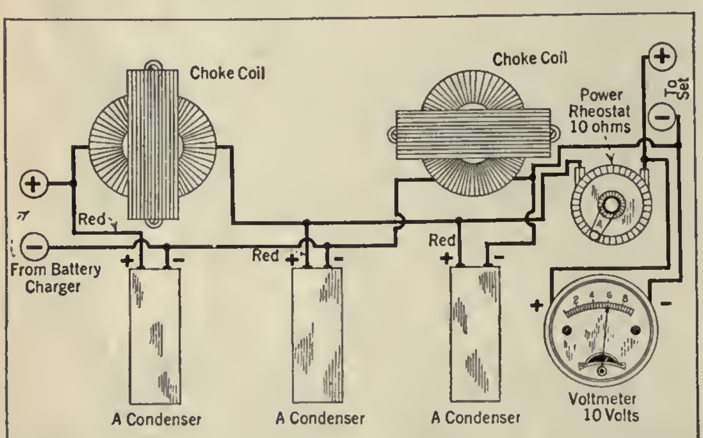


FIG. 5. A BASEBOARD LAYOUT OF THE FILTER SYSTEM

Two choke coils, three A-type condensers, a rheostat, a voltmeter, and four binding posts are indicated in this baseboard layout of a filter system for an A-power unit. Connect a battery-charger to the two left hand terminals and you have a source of filament current for your radio receiver. Operation of your radio receiver direct from the light socket is then possible using standard storage battery type tubes, such as the 201-A. Note in this baseboard layout of apparatus that the two choke coils have been placed at right angles to each other so as to eliminate any possibility of coupling between them. Be sure to note the markings (or color of the wire) on the A-condenser and connect them as indicated in this drawing

FIG. 4. PARTS FOR USE IN AN A-POWER UNIT

New Apparatus

To Help Cure Interference

X39

Device; Davis Trouble Finder, Model T. F. 2. A compact portable radio receiving set for use in locating sources of radio interference. The set uses five CX-299 (UX-199) tubes in a circuit consisting of two stages of r.f. amplification, detector and two stages of a.f. amplification. A single dial is used to tune the receiver. The other controls are a volume control, a rheostat and an "audio-radio" switch.

The set is designed for use with headphones, which are furnished with the receiver. An external loop of larger dimensions than the regular internal loop is provided. There is also provided a small exploring coil to be used as a loop where minimum sensitivity is required. Size: 14 x 10½ x 5¾ inches. Weight: 20 lbs. *Manufacturer:* Davis Emergency Equipment Company. *Price:* $225.00 complete.

Application: This excellent receiver, an earlier model of which proved exceedingly useful in the Laboratory some months ago, is the only one of its kind—that we know of—being manufactured for the specific purpose of locating sources of interference. With the receiver is supplied a small booklet giving data on the use of the device. The "audio-radio" switch is a valuable feature. It functions, when thrown to the "audio" side, to cut out of the circuit the r.f. stages, so that only the audio amplifier is operating. The manufacturer's pamphlet describing the receiver states that, "No case has yet been observed where interference was audible, on the audio side, beyond a limited area, usually within 150 feet of the source of interference."

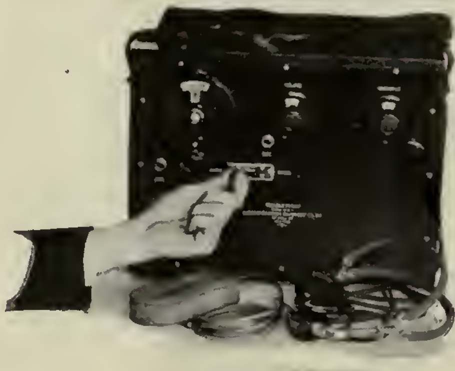
After the source of interference has been located, it must be repaired and in this connection the series of articles in Radio Broadcast, by A. T. Lawton, on how to eliminate interference, will be useful. These articles appeared in the following issues: November, 1927, January, 1928, and March, 1928.

A. C. Tube and Set Tester

X40

Device: Sterling A.C. Tube and Set Tester. Universal Model No. R-512. Contains an a.c. voltmeter with two ranges, 0-3 volts and 0-15 volts and a volt-milliammeter reading voltages up to 200 and milliamperes up to 30. It is possible with the tester to check the plate current

STERLING A.C. TUBE AND SET TESTER



DAVIS TROUBLE FINDER

of all types of tubes in an a.c.-operated receiver, test for open circuits, shorts, defective transformers, defective sockets, etc. The tests possible with this tester are divided into two general classes, so called "service tests" and "tube tests." The "service tests" check the characteristics of the receiver; determine whether or not the tube is being supplied with its rated filament and plate voltages, etc. The "tube tests" check the performance of the tube, determine if it has sufficient emission, whether it is amplifying, etc.

The tester can be used with receivers using R. C. A. and Cunningham, Ceco, Arcturus, Marathon, McCullough, Sonatron, Van Horne and any other a.c. tubes requiring filament voltage not in excess of 15 volts (the maximum voltage which can be read on the filament voltmeter). *Manufacturer:* The Sterling Manufacturing Company. *Price:* $35.00

Application: Radio service men, dealers, set builders, experimenters, will all find this tester useful. It is comparatively inexpensive and is accurate enough for all ordinary testing.

To use the device a tube is removed from the receiver under test and the plug from the tester inserted in the tube socket. The tube itself is plugged into a tube socket on the tester. By pressing the button on the tester it is possible to read plate voltage, plate current and filament voltage. All of the readings are taken under operating conditions and are therefore exact indications of the voltages applied to the tube when it is actually in operation. Either four-prong or five-prong tubes can be tested by means of adapters supplied with the tester.

PRODUCTS of radio manufacturers whether new or old are always interesting to our readers. These pages, a feature of Radio Broadcast *explain and illustrate products which have been selected for publication because of their special interest to our readers. This information is prepared by the Technical Staff and is in a form which we believe will be most useful. We have, wherever possible, suggested special uses for the device mentioned. It is of course not possible to include all the information about each device which is available. Each description bears a serial number and if you desire additional information direct from the manufacturer concerned, please address a letter to the Service Department.* Radio Broadcast, *Garden City, New York, referring to the serial numbers of the devices which interest you and we shall see that your request is promptly handled.*—The Editor.

Phonograph Pick-Up

X41

Device: Erla Phonograph Pick-up Unit. This device, illustrated in the photograph, is sold complete with the tone arm and volume control. The small movable arm carrying the actual pick-up is counterbalanced so that the needle will not press too heavily on the record.

To install the device, it is mounted on the phonograph in such a position that when the arm is moved to the center the needle is directly over the center of the record. The base of the tone arm is then fastened in this position with three wood screws..

Manufacturer: Electrical Research Laboratories. *Price:* $19.50

Application: Designed for use in conjunction with a phonograph turn table and an audio amplifier (contained in a radio receiver or separately) to enable one to reproduce phonograph records electrically.

The counterbalancing arrangement used in this device to offset some of the weight in the pick-up is to be recommended. Some of the pick-ups which have been tested in the laboratory press altogether too heavily on the record. A member of the Laboratory's staff, witnessing a

ERLA PICK-UP

demonstration a short while ago of a Hewlett loud speaker located at the Schenectady plant of the General Electric Company, noted that the pick-up unit used in the demonstration was arranged with a counterbalance, similar to that used in the Erla pick-up.

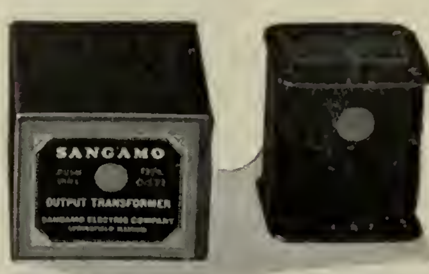
The Erla unit gave a quality of reproduction apparently about equal to that of other pick-ups the Laboratory has received for test, but the volume output was somewhat less. However, the Erla unit gave all the volume needed for ordinary home reproduction.

Five New Audio Coils

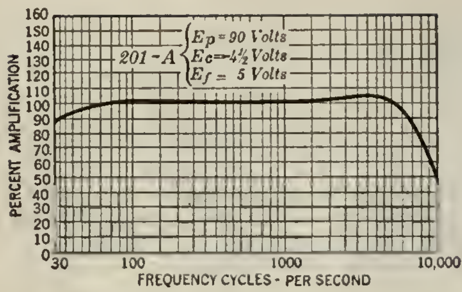
X42

Device: Sangamo Audio Apparatus. The following units are available:

Audio Transformer Type A. Turns ratio 3, primary resistance 1960 ohms, secondary resistance 7100 ohms, primary inductance 200 henries with no direct current, with 2 mA. direct current, 145 henries. *Price:* $10.00. Output Impedance Type E. With 25 to 28 mA. of d.c. flowing through the coil the inductance is 30



SANGAMO OUTPUT TRANSFORMER



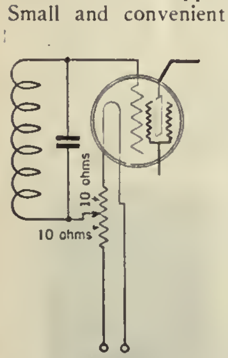
AMPLIFICATION CURVE OF THE SAGAMO TYPE A AUDIO UNIT

henries. *Price:* $5.00. Plate Impedance Type F. Designed for use in impedance-coupled amplifiers or as audio-frequency choke coils in the plate leads to prevent oscillation and motor boating in audio-frequency amplifiers. Inductance about 200 henries. *Price:* $5.00. Push-pull Input Transformer Type B. Ratio 4.5 to 1. *Price:* $12.00. Push-pull Output Transformer Type C171. For use in push-pull amplifiers using 171 type tubes. Impedance step down ratio 2:1. Total primary inductance 80 henries. *Price:* $12.00. Push-pull Output Transformer Type D-210. For use with push-pull amplifiers using 112 and 210 type tubes. Total primary inductance 100 henries. *Price:* $12.00.
Manufacturer: SANGAMO ELECTRIC COMPANY.
Application: The above apparatus may be used in constructing transformer impedance-coupled amplifiers. The Type A audio transformer, using a special alloy core, has the disadvantage that the ratio is somewhat low so that a two-stage affair will not have any too much gain. With two of these transformers and a 201-A type tube in the interstage the voltage gain from the output of the detector to the grid of the power tube will be about 6.3. To load up a 171 type tube the detector output will have to be about 0.7 peak volts. However, the frequency characteristic of the transformer, as announced by the manufacturer, and which we consider to be trustworthy, is very good and the excellent frequency transmission which the transformer will give compensates their rather low gain.

The output impedance, Type F, is arranged with terminals so that it is possible to use it with different types of power tubes, and adapt their impedance to that or ordinary types of loud speakers. A condenser with a capacity of about 4.0 mfds. must be used in constructing a complete output device using this impedance.

Center-Tapped A. C. Tube Resistors

X43
Device: Center-Tapped Resistors type CU-20. Small and convenient center-tapped resistors designed especially for use across the filament circuits of a.c. tubes. They measure about 2 inches long and about $1\frac{3}{16}$ inches wide. Available in resistances up to 100 ohms. *Manufacturer:* CARTER RADIO COMPANY. *Price:* $0.25.
Application: Circuits using a.c. tubes generally require one or more center-tapped resistances across the filament circuit. The 20-ohm size in this type of resistance may also be put to very satisfactory use in the filament circuits of screen-grid tubes. Twenty ohms is just right to reduce the storage battery voltage of six to the 3.3 volts required by the screen-grid tube. The center tap in the resistance may be used for the grid circuit return as shown in the circuit diagram, and a C bias of 1.3 volts obtained in this way



CENTER-TAPPED RESISTOR
In the grid circuit return

Antenna Tuning Unit

X44
Device: Sickles Intensifier. A unit to be attached to a receiver to obtain greater volume. It consists of a coil and a condenser mounted in a small box and functions to tune the antenna circuit to resonance. *Manufacturer:* F. W. SICKLES COMPANY. *Price:* $7.50
Application: If the antenna circuit of a receiver is tuned by means of a coil and a condenser it is generally possible to obtain somewhat greater volume than can be obtained if the circuit is untuned.

Many modern single-control radio receivers use untuned antenna circuits and if one does not mind adding another control to the set it will be possible to increase the volume considerably by tuning the antenna circuit. The Intensifier is such a device and may be easily added to most any type of receiver. The idea is not new—especially to radio experimenters—but in this device the idea has been put into workable form so that an average person, knowing little or nothing about radio circuits, may be able to use it to advantage. This is a good gadget for the radio service man to handle and to make use of in those cases where a customer complains of insufficient volume.

SICKLES INTENSIFIER

A. C. Tube Filament Transformers

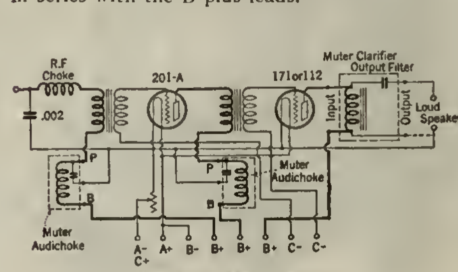
X45
Device: A. C. Filament-Lighting Transformers. Ten different types of filament transformers are made with specifications as given below.

No. 6512. Designed for one to four UX-226, one UY-227 and one UX-171 or two UX-171A. Transformer is mounted in crystallized lacquered case equipped with lamp cord and plug outlet, also tap for control switch. $1\frac{1}{2}$ V., 4.2 amp.; $2\frac{1}{2}$ V., 1.75 amp.; C. T., 5 V. $\frac{1}{2}$ amp. *Price:* $5.75. No. 6515. Same as above without plug outlet and control switch tap. *Price:* $4.75. No. 6570. Same as 6512 but with terminals on secondary. *Price:* $6.50. No. 4586. Designed for one to eight UX-226, two UY-227 and two UX-171, $1\frac{1}{2}$ V. 8.4 amp., $2\frac{1}{2}$ V. 3.5 amp. C. T., $7\frac{1}{2}$ V. $2\frac{1}{2}$ amp. C. T. *Price:* $8.00. No. 4587. Designed for one to eight UX-226, two UY-227 and two UX-210, $1\frac{1}{2}$ V. 8.4 amp., $2\frac{1}{2}$ V. 3.5 amp. C. T., $7\frac{1}{2}$ V. $2\frac{1}{2}$ amp. C. T. *Price;* $8.00. No. 6513. Designed to operate one to six Arcturus a.c. tubes. Transformer is mounted in crystallized lacquered case equipped with lamp cord and plug outlet for B power unit, also tap for control switch. 15 V., 2.1. amp. *Price:* $5.25. No. 6511. Same as above without plug outlet and control switch tap. *Price:* $4.25. No. 286. Designed for heating filament of one UX-210. $7\frac{1}{2}$ V., $1\frac{1}{4}$ amp. C. T. *Price:* $2.50. No. 287. Designed for heating filaments of two UX-171 or UX-112 power tubes, 5 V., 1 amp. C. T. *Price:* $2.50. No. 820. Designed for heating one to eight McCullough (Kellogg) a. c. tubes, 3 V., 8 amp. C. T. *Price:* $6.00.
Manufacturer: DONGAN ELECTRIC MANUFACTURING CO.
Application: These transformers are to be used as a source of filament current for a.c. tubes in the construction of light-socket-operated receivers making use of any of the well-known types of a.c tubes. This line of transformers satisfies the demands of the valve combinations found in most receivers in use to-day.

Choke-Condenser Unit

X46
Device: Audichoke. A combination of a choke coil and a by-pass condenser, both contained in a single case. The chokes are rated at 100 henries with a d.c. resistance of 445 ohms and the condensers have a capacity of 1.0 mfd. *Manufacturer:* LESLIE F. MUTER COMPANY. *Price:* $5.00.
Application: The internal impedance of power units and old B batteries is frequently sufficiently high to cause an audio amplifier to begin to oscillate and, sometimes, to motorboat due to common coupling owing to the power unit's impedance. In the ideal case, the amplifier should be absolutely independent of its power supply so that it is entirely unaffected by the impedance of the source of power—but unfortunately in practice this is rarely the case. The receiver may be made practically independent of the power supply by properly filtering the plate by means of choke coils or resistances in conjunction with by-pass condensers. This Audichoke is a device of this sort making use of a choke coil and 1.0-mfd. by-pass condenser. The connection of the unit in a typical amplifier is shown in the circuit diagram.

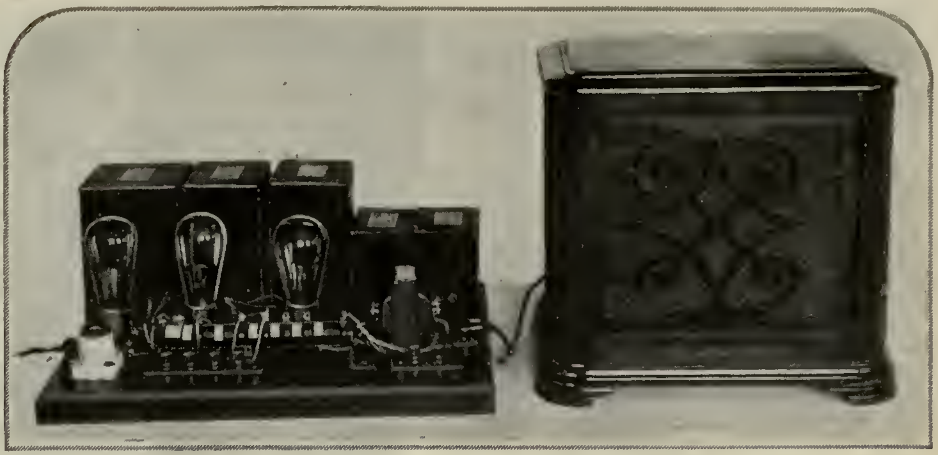
There is no reason for the use of this device in an amplifier that is giving satisfactory operation, but in cases where the amplifier oscillates or motorboats these choke-condenser units may be included in the circuit. In making use of these units it is generally not necessary to revise the amplifier; the chokes may simply be connected in series with the B-plus leads.



MUTER CHOKES IN AN AUDIO SYSTEM

THE COMPLETED POWER AMPLIFIER AND A DYNAMIC TYPE LOUD SPEAKER

This high-quality power amplifier, built around the type 250 tube, must be used with the better types of loud speakers if the builder is to obtain from the unit the quality it is capable of producing. This photograph shows the amplifier in conjunction with the Jensen dynamic loud speaker



A Good Amplifier-Power Unit for the 250 Tube

By HOWARD BARCLAY

WE PROPOSE to describe here a single-stage power amplifier and B supply designed for use with the new type 250 tube. In the following paragraphs we review the general characteristics of this power amplifier and call attention to the interesting features that have been incorporated in it. Sufficient constructional details are given so that the amplifier may be readily constructed by those interested readers to whom this unit appeals.

This power amplifier and B supply is designed for use as a last-stage amplifier. The receiver proper must contain at least two stages of resistance-coupled amplification or one stage of transformer-coupled amplification in order that the overall gain of the system shall be sufficient to operate the power tube. A combination amplifier and B-supply unit of this type can also be used to considerable advantage to replace the output stage in a radio receiver not using power tubes or in cases where more volume is desired than can be obtained from the smaller types of power amplifier ordinarily used in radio receivers. Service men and professional set builders may find the construction of an amplifier of this type advisable for customers desiring the utmost in quality reproduction and who desire comparatively large amounts of volume such as is necessary in reproducing radio programs for dances in clubs, and in other large public rooms.

The output of this single type 250 tube is about equal to the power output of an amplifier using type 210 tubes in push-pull. More specifically, the rectifier-filter system used in this power unit is such that the plate of the 250 tube receives about 400 volts at which voltage the tube can deliver 3.25 watts. This amount of power is in excess of what is ordinarily required for home reproduction but will not be excessive when the radio installation is called upon to supply more volume—sufficient, for example, for dancing. The construction of a power amplifier that can deliver more power than is ordinarily required falls into the same category as the purchase of an automobile with an 80 horsepower engine. The maximum output of the device may seldom be required, but is available when necessary. [The reader should refer to the article "The Newest Power Tube," by Howard E. Rhodes on page 74, RADIO BROADCAST, June, 1928. Here the potentialities of the 250 type tube were most thoroughly analyzed and compared with other power tubes that are available to the radio fan and professional set builder.—*Editor.*]

THE CIRCUIT IS INTERESTING

THE circuit diagram of this power amplifier and B supply is given in Fig. 3. The circuit contains two innovations. In the first place a small flashlight bulb, indicated as B in the diagram, is connected in series with the output of the rectifier tubes, to protect the rectifier tubes from damage in case the output of the filter system is accidentally short-circuited or in case the type 250 tube is placed in the socket and operated at less than normal bias so that the plate current is excessive. In such cases the small flashlight bulb will glow very brightly or will burn out and thereby warn the user of the device that there is some defect in the circuit.

The filter system used in this device is unusual in that the condenser connected across the input to the filter system is eliminated and in this case is connected instead to the center point of the two filter choke coils, L_1. There is no condenser connected across the input to the filter system. This revised circuit is used in accordance with recommendations to be found in the Cunningham *Tube Data Book.* [Available from E. T. Cunningham, Inc. at $2.50.—*Editor.*] Curves are given in this book indicating that with the familiar type of rectifier and filter circuit, Fig. 1A, the load on the rectifier tube is quite heavy, reaching during each cycle, current values as high as 300 milliamperes although the average current drawn from the filter system was only 125 milliamperes. Under such conditions the rectifier tubes are therefore called upon to supply a peak current about two and one half times as great as the load current (300 divided by 125) and thus the filament of the rectifier must be made heavy and long enough to supply this large amount of current.

THIS article describes a very satisfactory power supply and amplifier unit using the new type 250 amplifier tube. Technically, the device has two especially interesting and unusual features. In series with the rectifier output a small flashlight bulb is included. This operates to protect the rectifier tubes from damage in case of an accidental short-circuit. A new type of filter circuit is used, which gives longer rectifier tube life than that usually obtained in the usual type of filter system. This unit tested out very well in the Laboratory. The quality was very good and the a.c. hum was practically inaudible in the dynamic loud speaker which was used.

—THE EDITOR.

A very great improvement in these load conditions can be obtained by removing the condenser, C_1, across the input to the filter system, as indicated in Fig. 1B. Under such conditions the peak value of current which the tube must supply is reduced to only 140 milliamperes in comparison with the value of 300 milliamperes which the tube is called upon to deliver when the condenser was included in the circuit. This reduced current drain on the tube results in much longer filament life. The omission of the first condenser from the filter system would normally cause a reduction in output voltage but this can be compensated by slightly increasing the transformer voltages. The power unit described and illustrated in this article makes use of this new filter system so that the user can obtain from the rectifiers as long a life as possible. The list of parts on page 142 are those used in constructing this amplifier.

ASSEMBLY AND OPERATION

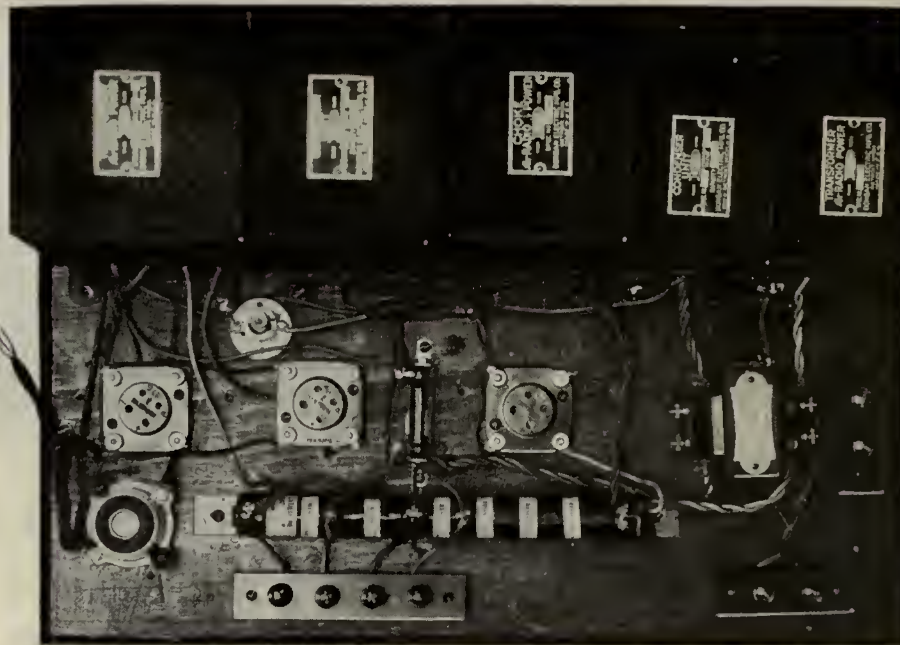
THE wiring of the amplifier is not difficult, using the information given in Figs. 2 and 3. The various transformers, chokes and condensers are supplied with insulated leads sufficiently long so that most of the wiring may be done with them. The leads are colored in accordance with the markings on the diagram. If it is necessary to use any additional hook-up wire it should be of the heavy insulated rubber type not smaller than size No. 18. [The unit described here was made with parts from the Dongan Company and it performs very satisfactorily indeed. Obviously, if the builder prefers, he can assemble a similar amplifier and power supply employing the necessary units made by other reliable manufacturers. We recommend that only 1000-volt test condensers be used in the filter. The "New Apparatus" department, page 85 June issue, and that department in this issue, as well as our advertising pages, give information on the products which might be used.—EDITOR.]

As indicated in the picture diagram, Fig. 2, all of the cases of the transformers, filter chokes, and condenser blocks should be wired together and connected to the negative B. The filament leads of the rectifier tubes should be twisted together as should the filament leads to the type 250 power amplifier tubes to minimize any a.c. hum.

It is useless to construct a quality amplifier

of this type unless all of the apparatus used in conjunction with it is also of the best. The output of the amplifier should be fed into a good cone or dynamic type loud speaker such as the Magnavox or Jensen. In operating the unit care must be taken that it is so located to provide sufficient ventilation for the tubes. The 250 type amplifier, especially, becomes very warm in operation. If the unit is placed inside of a cabinet it will be a good idea to tack a piece of asbestos above the amplifier to protect the cabinet from the heat.

Take care in constructing this amplifier. Remember there are many kinds of accidents. One is the useful that leads to discoveries and inventions. Another kind, somewhat different, and sometimes associated with the construction of high-voltage amplifiers, leads to burnt finger tips or perhaps to severe shocks. The voltages used in this and other types of amplifiers using 210's and 250's are positively dangerous and every precaution must be taken in wiring and handling the amplifier so that there is no possibility of shock. Do not make any changes in the amplifier while the power is on.



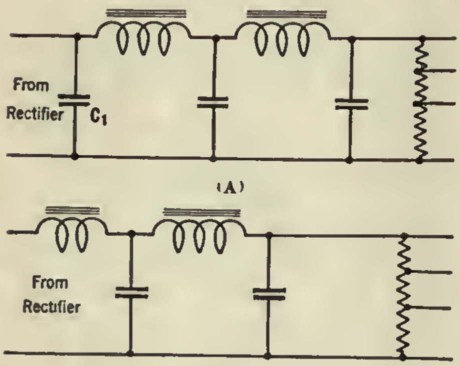


FIG. 1

Sketch A illustrates a typical filter circuit such as is incorporated in the usual B-power unit. Sketch B shows a modification of this circuit, condenser C_1 being omitted, which greatly reduces the peak value of current which the rectifier tube is called upon to deliver. This improvement has been incorporated in the power amplifier described in this article

LIST OF PARTS

T_1	Dongan Transformer No. 7568	$ 13.50
T_2	Dongan Output Transformer No. 1177	12.00
T_3	Dongan Type H Audio Transformer Ratio 3½–1	4.50
L_1	Dongan Double Choke Unit No. 6551	15.00
C_1	Dongan Condenser Unit No. D-600	23.00
C_2	Dongan Condenser Unit No. D-307	10.00
R_1	Ward Leonard Resistor No. 507-6	6.75
R_2	Ward Leonard Resistor No. 507-55	1.00
2	UX-281 or Cunningham CX-381	15.00
1	UX-250 or Cunningham CX-350	12.00
3	Benjamin Sockets	2.25
1	Porcelain Socket for Fuse	.25
1	3 Amp. Clearsite Fuse	.15
8	Eby Binding Posts	1.20
B	Flashlight Bulb and Socket	.50
1	25-ft. length Belden colorubber hookup wire	.50
	Baseboard, Wood Screws, Bakelite Strips, etc. Approx.	1.00
	TOTAL	$116.25

The following additional items are required in order to make the device operative.

2 CX-381 (UX-281) Rectifier Tubes
1 CX-350 (UX-250) Power Amplifier Tube

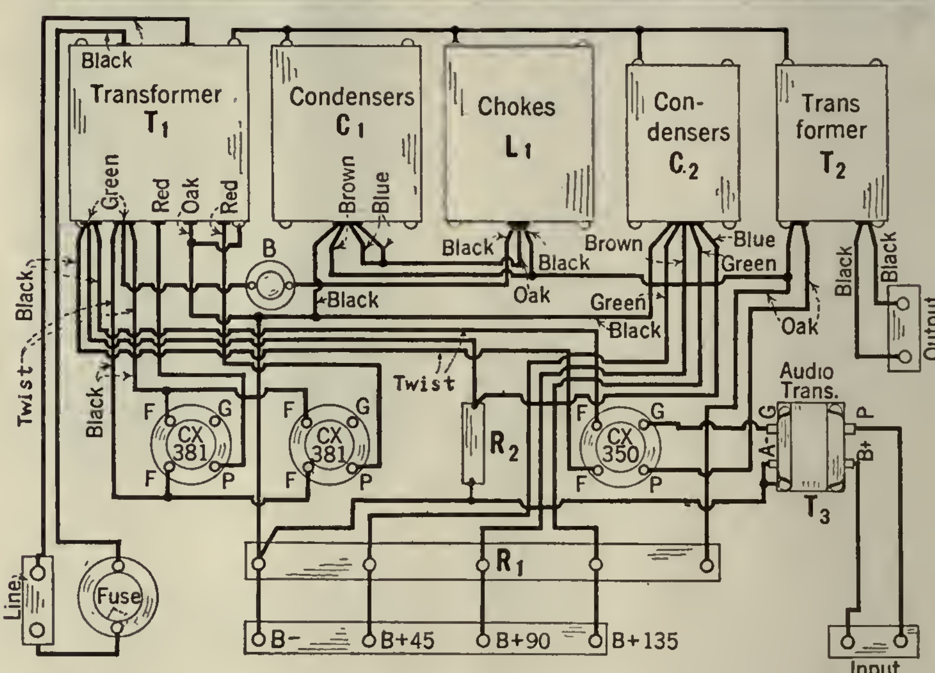


FIG. 2

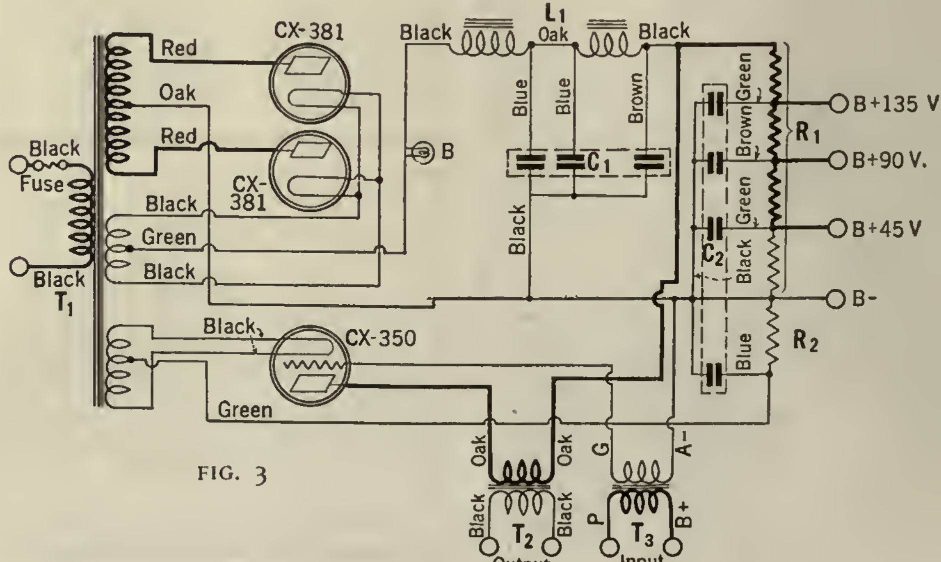
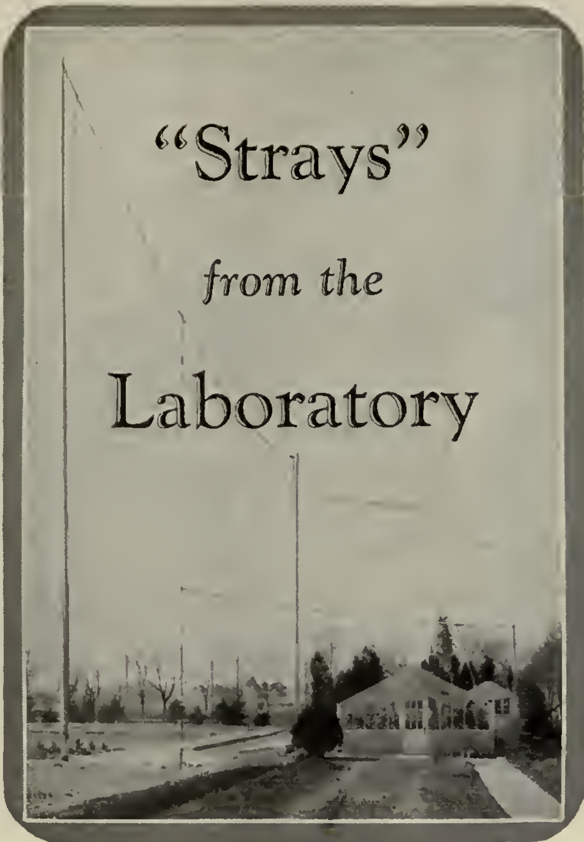


FIG. 3



"Strays" from the Laboratory

New Crystal Control

We have already mentioned the extreme accuracy to which broadcasting stations must be kept on their required frequencies if there is a general exodus of stations down to the short waves—or into the higher frequencies. Now we learn from the March, 1928, *Bell Laboratories Record* that crystal control apparatus has been developed for use with television equipment which is capable of holding oscillators to a constant frequency to within one part in ten million. This is equivalent to one cycle in 10,000 kc. (30 meters). At present, broadcasters seem to have difficulty in holding to 500 cycles at 1000 kc. This shows that such accuracy of adjustment and maintenance can be obtained.

The objection, from the broadcasters of course, is that such equipment costs a great deal of money. We do not believe this is a valid objection. There is a great deal of money invested in radio receiving equipment at the present time—much of which is wasted because of present conditions in the ether. It costs a lot of money to wage war, and many years afterward to pay for it, but at the time nearly everyone gets highly enthusiastic about it.

When controlled by these crystals, a driving motor of a television receiver would require a week to get out of step with a transmitting motor by as much as one revolution. This eliminates the tendency of a television image to slowly float off the screen.

Prices of British "Components"

The following prices taken from a recent issue of the British publication *Wireless World and Radio Review* are indicative of what the Britisher has to pay for his radio apparatus:

Amplion Cone Speaker	$ 7.00
Siemens B batteries, power type . .	3.00
Weston Set Tester	75.00
Cosmos High-mu tube, μ-35, R_p-50,000	2.00
Cosmos power tube μ-6.5, R_p-4500 ohms	2.50
Brown phonograph pick-up	20.00
Carborundum resistance-capacity unit	1.75
Ferranti output transformer 1–1 . .	6.50
Dubilier phonograph pick-up . . .	7.00
Marconiphone power supply unit. .	37.00
Magnavox dynamic speaker unit. .	47.00
Mullard audio transformer, high quality	5.00
Ormond five-tube portable receiver .	122.00
Benjamin sockets	.50
General Radio speaker filter . . .	6.00

In this issue are no less than twelve advertisements of moving coil loud speakers, represented in this country by the Magnavox, the R.C.A. 104, and the Jensen, there is also an extraordinary radio-phonograph outfit consisting of two tone-arms, two pick-ups, two turn tables, and two motors—all for $180.00. The reason for the duplicate list of parts is not stated.

Present Interesting Trends in Radio

It begins to look as though the English have been considerably in advance of us in the development of moving coil—dynamic type, if you will—loud speakers. For many months the English papers have had descriptions of such instruments pointing out their superior characteristics compared with both horn and cone speakers, and the advertising pages of these magazines have been correspondingly full of copy from manufacturers of the newer type of speaker. We predict that next year will see a flood of moving coil speakers in this country, mounting to a new craze on the part of our radio public.

We have already mentioned the superior qualities of the Magnavox and Jensen speakers. We have recently seen a curve which we believe to be truthful—which shows a uniform response from below 35 cycles to above 6000 when a unit of this type is used with a rather large and awkward baffleboard. We do not believe it necessary to go down to 35 cycles for excellent quality—but it is comfortable to know your automobile can go 75 miles an hour even though you haven't the nerve to drive it at that rate.

The trend toward dynamic speakers is already evidenced in the interest shown on Cortlandt Street, the cut-rate market of New York. Here are a half dozen imitations of the real thing which the gullible radio public is buying as fast as it can. It is reported that several receiver manufacturers whose names are well known are interested in the dynamic speaker and that several have already made arrangements for using it in 1929 models.

There is another trend which seems to be becoming more and more pronounced. This is the search for some method of solving the a.c. receiver problem whether by series-filament systems or by voltage control units which maintain voltages both A and B constant in spite of varying line voltages.

We have seen several of the voltage regulators which as yet are not ready for the market. One in particular delivered A and B voltages with variations of not over 1 per cent. in spite of line fluctuations of over 30 per cent.

There is some interest at this time in running filaments in series, such as was described by Roland F. Beers in Radio Broadcast many, many months ago. The advent of eighth-ampere filament tubes will make this problem much simpler, for it is not difficult to obtain currents as high at 135 milliamperes from modern rectifier-filter systems. Just when these tubes will appear is not known, although a recent Sonatron catalogue lists them as being ready for sale at once.

And speaking of trends—someone has suggested that people who object to the high voltages necessary for 210 and 250 type tube operation, where considerable audio power is desired or necessary, might use four 171's in parallel. The plate current drain would be about the same as for a 250 type tube, but the voltage need not be over 220 for a combined B and C voltage supply system. This is to be compared with 500 necessary to provide the newest power tube with proper operating conditions. Four 171's will deliver nearly 4 watts of power, and will present an output impedance of about 500 ohms which ought to bring out enough low notes, without distortion, to suit anyone. With the proper output transformer this amplifier output ought to work into a dynamic speaker with its usual 5- to 10-ohm impedance.

The curve in Fig. 1 is that of the Amertran output transformer designed to couple push-pull 210 tubes to a dynamic speaker.

Radio Gossip

The Kodel Radio Corporation announces it has paid $250,000 for the invention which led to the development of Kuprox, a rectifying element. This sum bought approximately 35 patents. During the past six months royalties in excess of $100,000 were paid to the Leibel-Flarsheim Company of Cincinnati for devices using this material which was developed in their laboratories.

The Arcturus Radio Company, makers of tubes, announced a '27 type replacement tube with a guaranteed life of 1000 hours. This has been possible by designing a heater and cathode combination in which the filament or heater burns at a very low temperature. The lag in time between turning on the current into this new tube and its functioning properly, which in some tubes is about 42 seconds, has been reduced to six from fifteen seconds by decreasing the spacing between heater and cathode. The increase in heating varies roughly as the square of the de-

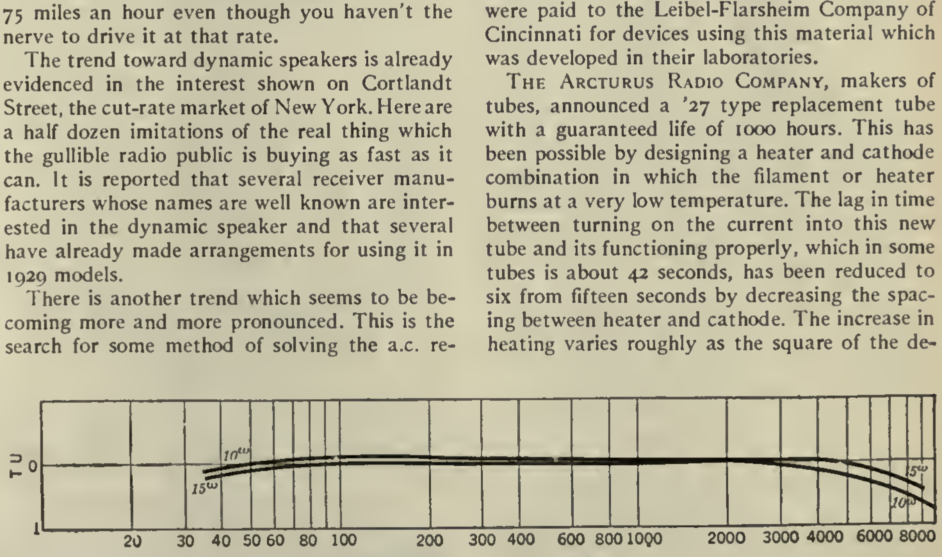


FIG. 1

Frequency characteristic of the Amertran type 200 push-pull output transformer working out of two 3000-ohm tubes into 10- and 15-ohm resistances

crease in spacing. Variations of line voltage up to 25 per cent. can be tolerated with this tube.

FORTY-EIGHT months ago we watched Austin G. Cooley transmit pictures across the RADIO BROADCAST Laboratory and wondered when it would be possible to turn his work over to the thousands of experimenters in this country. We now have a circular from the Radiovision Corporation, 62 West 39th Street, New York City, which announces that the Cooley Rayfoto kit is ready for sale and that pictures are being regularly transmitted from WOR.

Publications Worthy of Note

THESE BOOKLETS have come to our attention and deserve the praise of a review. However, their titles indicate enough of their contents to be of interest to those working in any of the subjects covered:

GENERATOR FOR AUDIO CURRENTS OF ADJUSTABLE FREQUENCY WITH PIEZO-ELECTRIC STABILIZATION, BY AUGUST HUND. *Scientific Paper of the Bureau of Standards, No.* 569, Price 10 cents.

How to Operate Any Receiver from the House Current without Batteries. ARCTURUS RADIO COMPANY, 255 Sherman Ave., Newark, New Jersey.

A RADIO-FREQUENCY OSCILLATOR FOR RECEIVER INVESTIGATIONS, BY GEORGE RODWIN AND THEODORE A. SMITH. *Institute of Radio Engineers*, (reprint). February 1928 issue.

CALCULATION OF CAPACITIES OF RADIO ANTENNA AND THEIR RESULTANT WAVELENGTH, BY FREDERICK W. GROVER. *Scientific Paper of the Bureau of Standards No.* 568, price 20 cents.

National Electrical Safety Code, Fourth Edition 1926, HANDBOOK SERIES OF THE BUREAU OF STANDARDS, *No.* 3. Price $1.

Data on the Voltage Amplification of Radio Frequency Transformers, by Burr K. Osborn. BULLETIN NO. 15, Michigan Engineering Experiment Station, Michigan State College, East Lansing, Michigan.

What B Eliminator Shall I Buy? Electrad, 175 Varick Street, New York City.

"Skim Milk Masquerades As Cream"

ONE OF our service-dealer friends sends us what he considers a good joke on himself. Recently he gave a wholesale firm a trial order for some output transformers which would retail at $1.50. When the transformers—so called—arrived he attempted to measure the resistance, to get an idea of the inductance, and found that the coils would pass one ampere at 85 volts, and when the cover was torn off he discovered a solid pig-iron core and two coils connected as shown in Fig. 2. When the coils were so connected between tube and loud speaker that energy transfer was inductive rather than conductive, nothing got through because of the extremely low inductance. In other words instead of a transformer, our friend had bought two coils which were to be placed in series with the loud speaker. The iron was thrown in. How many of RADIO BROADCAST's readers have been taken in by such devices?

Technical Smoke Screen

WILL ANY technically minded reader interpret this quotation from the April, 1928, *Popular Radio* (page 303),

> During tests that were conducted in the *Popular Radio* laboratory it was found that this cone could easily take an output of two 210 amplifier valves arranged in a push-pull stage. The output current during the test ran as high as 49 milliamperes, with voltage on the lower end of the frequency range varying between 1000 and 1280. The speaker performed remarkably well with this great load and was free not only from standing waves, but from harmonic distortion as well.

Recent Interesting Technical Articles

THE FOLLOWING articles in technical radio publications are to be recommended:

Measurement of Choke Coil Inductance, *Proceedings I. R. E.*, March.
Mutual Inductance in Radio Circuits, *Experimental Wireless*, April.
Calculations for Resistance Amplifiers, *Experimental Wireless*, April.
Low-power Crystal-Control Transmitters, *QST*, April.
Design of Iron-Core Inductances, *QST*, April.
Photoelectric Cell Applications, *Popular Radio*, April.
Geophysical Prospecting, *Scientific American*, May.
The Stabilized Oscilloscope, *Radio Engineering*, April.
The Neutroheterodyne, *Radio News*, May.
Regeneration, What it is, *Radio News*, May.

Present Compression-Type Resistors

WE ARE glad to quote the following from a letter of Mr. Austin C. Lescarboura, apropos of an article on page 421 of the April RADIO BROADCAST in the department "Our Readers Suggest."

> Because of my extensive experience with all types of resistors, I wish to point out that the "additional precaution" of Mr. Harries is somewhat misleading. There are variable resistors to-day quite as reliable and as silent in operation as the wire-wound type. While it is true that the carbon-pile type is often noisy and microphonic, due to loose contacts between the carbonized paper disks made necessary in attaining a wide resistance range, there is none of this feature in the compression type utilizing graphite and pulverized mica. In the latter type there is always sufficient compression of the resistive material to insure perfect contact free from microphonism, although the widest possible resistance range is obtained in several turns of the knob. While in the past there may have been limited use for the compression type variable resistance, to-day, with various sizes up to and including a power type capable of handling 40 watts of energy, there is no reason to turn to fixed wire-wound resistors even in the large power packs and A-B-C power units.

From a Lab Circuit Fan

THE FOLLOWING letter from A. S. Penoyer of Saginaw, Michigan, pleased the Laboratory Staff a lot; fortunately it is but one of many in a similar vein:

> To you this letter will mean just another from a new R. B. Lab. circuit fan; but to me the circuit is little less than a revelation. I am well repaid for having disassembled a mighty fine seven-tube super to acquire parts for the Lab. circuit.
>
> I have been an ardent super fan since the days when you published Haynes' super article four or five years ago, and during that time have built and rebuilt several. Your last article in the April issue convinced me that you have something good. Yet it was with misgivings that I removed the first wire from Old Faithful; and when, due to the omission of a wire to ground from by-pass condensers the Lab. circuit motor-boated mightily, I cussed my temerity in proportion. But now, well it's a "wow" and I wouldn't trade it for anything I have seen.
>
> The coils I am using are home-made, but judging from results must be pretty good. All of the other parts are of the best and the layout is approximately as suggested in your April article. Selectivity is excellent and I am listening to stations I haven't heard in some time. The volume equals the super and the tone is round, full and very real and I'm critical too.
>
> Just why more than four tubes are necessary, I can't understand. I am fully "sold" and wish to express my appreciation of your April article. The May issue has not as yet arrived so I don't know what your constructional article is to be, but am sure it can't improve my set.

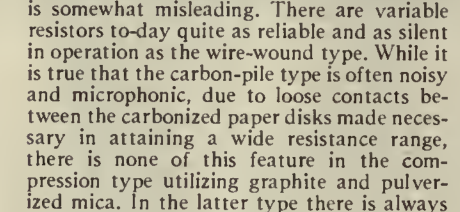


FIG. 2

What was actually inside an "output transformer" purchased at a low price by a radio service man. Pig iron was used to give the unit weight!

Who Our Readers Are

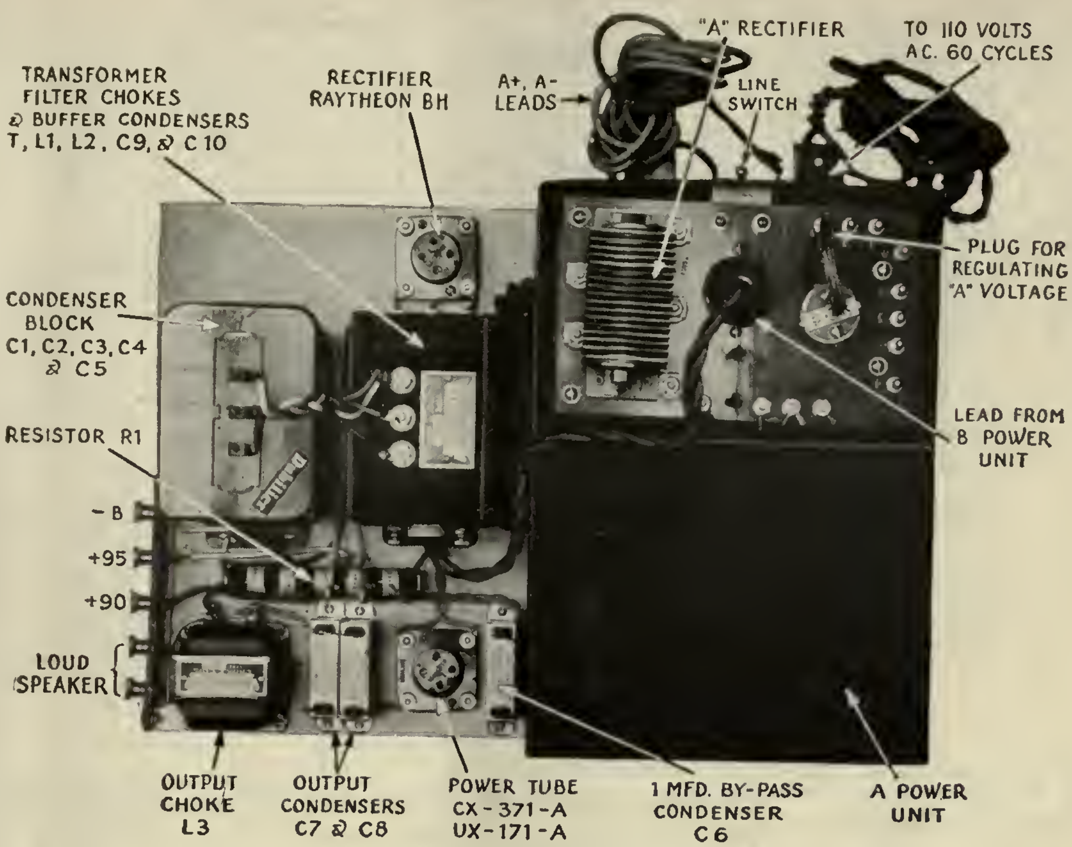
WE OFTEN wonder who the thousands of RADIO BROADCAST's readers, from whom we never get letters, are; what their business is, how they are interested in radio; how it is possible to get better acquainted with them. The following tabulation of one thousand readers is one year old but gives a good idea of who the magazine's audience was in February, 1927. What we should like is for one thousand present readers of these pages to write us a note, letting us know where on this list they are.

OCCUPATION	PER CENT. OF 1000
Radio dealers	26.7
Miscellaneous skilled workers	23.8
Engineers	11.0
Clerks	5.4
Executives	4.5
Salesmen	4.3
Electricians	4.1
Draftsmen	3.3
Accountants	2.5
Mechanics	2.3
Machinists	2.1
High school students	1.8
Technical institute students	1.3
Physicians	1.2
College students	.9
Lawyers	.9
Bookkeepers	.8
Tellers	.7
Chemists	.7
Dentists	.4
Pharmacists	.3
Miscellaneous	1.0

A Flux for Nichrome Wire

USERS OF nichrome and other resistance wire and who have had difficulty in soldering it will be relieved to know that John Firth of the Firth Radio Company, 25 Beaver Street, New York City, has developed a special flux with this difficulty in mind. It is known as Perfecto No. 2 and may be obtained in 25 and 50 cent bottles from the Firth Company.

—KEITH HENNEY



THE COMPLETED A-B-C-POWER UNIT

Assembled from parts generally available this A-B-C-Power unit may appeal to many constructors who have a good receiver which they do not wish to discard but who still would prefer to displace their battery supply and provide a modern last audio stage

An Interesting A-B-C-Power Unit and One-Stage Amplifier

By J. GEORGE UZMANN

Dubilier Condenser and Radio Corp.

"SAY Frank, I have a radio problem on my hands, and knowing all the time you've spent on broadcast receivers I thought perhaps you can help me out," was the way a friendly chat began.

"Surely, only too glad to be of service," and his friend inquired, "tell me all about it."

"Well I suppose I'm just like everybody else these days and want a completely electrified set. But in a way I hate like blazes to scrap my Neutrodyne which is just a little over a year old and tunes about as fine, and has tone quality almost as good as any I've heard; still on the other hand if it isn't the B-battery going bad why then it's the old storage battery quitting at just the wrong time. Yes, I suppose my trouble is simply batteries, batteries and then more batteries.

"Frank, tell me," he continued, "what make of electrified set would you buy? I can't make up my mind on this point, but it seems to me as though the cheapest receiver in the electrified class costs about $125 with tubes, if the ads mean anything at all. My present set cost a little over $175, and to think there is a 100 per cent. depreciation to be taken after a year's operation is hard to believe—that state of affairs surely would not get by in everyday business."

"Just a second, Lawrence; pardon my interruption, but I think I pretty well understand your problem, and if you will let me tell you of my experience along these lines during the past year, or say, ever since this a.c. tube question made itself felt, then perhaps you shall be better able to purchase the correct type of set or equipment with not only the least cash outlay but also without running into the usual grief." The radio expert with these few words had the pulse of the situation.

THE complete power unit supplying all receiver voltages and containing a type 171 audio amplifier stage described here is an excellent unit. Tested in the Laboratory of RADIO BROADCAST *on a standard battery-operated receiver, very little hum was audible on a high-quality loud speaker. Home constructors may be interested in duplicating this unit for it is highly satisfactory and comparatively inexpensive. The professional set-builder and service man will find in this device a popular replacement outfit for the power supply of battery-operated receivers with an insufficient last-stage audio amplifier.*

—THE EDITOR.

WHAT IS AN ELECTRIFIED RECEIVER?

THE above paragraphs in a few words describe the general thoughts and impressions which exist to-day in the minds of many who now own radio equipment. Gaining momentum, it seems as though everyone is interested in an "electrified set."

Yet strange as it may seem, very few people really realize just what sort of a set it must be. Evidently any receiver is "electrified" just so long as it operates without batteries. A radio trade paper recently made a canvass in effort to learn just what the public was thinking about regarding "electrified" equipment, and it is interesting to note that less than 10 per cent. of set owners had any conception at all about what

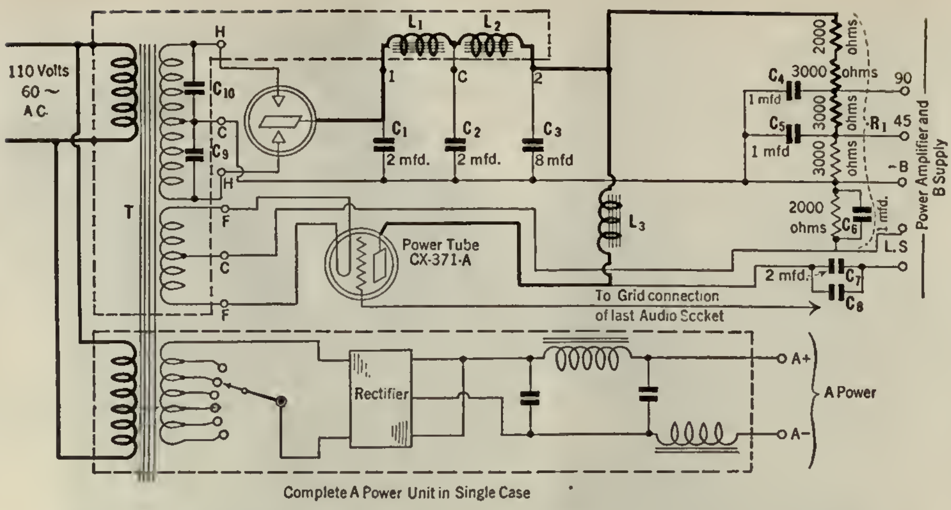


FIG. 1. THE CIRCUIT OF AN A- B- C-SUPPLY AND POWER AMPLIFIER

A power-amplifier and B-supply have been combined with an A-power unit in this unit so that the combination not only gives the constructor a stage of power amplification but also supplies to the receiver all the necessary A- and B-voltages. The various pieces of apparatus in this drawing have been lettered to correspond to the lettering on the picture diagram and photograph and list of parts in this article

made up such a set—evidently its name alone, or possibly the vague impressions of a.c. tubes, together with their novelty, etc., etc. has been the cause of building up the present runaway market.

It is true that with a.c. tubes plus the proper power supply modern receivers can readily be built which operate without the use of a single battery. The a.c. source of B and C voltage has been practically solved for two years or more because of socket-power devices but it is the appearance of the various substitutes for the A battery that have suddenly built the recent excessive demand for "electrified sets."

It does not make a particle of difference what sort of tubes one employs because each is a three-dimensioned device and thus calls for an A potential for heating the filament, a B voltage for its plate circuit, and in most cases an additional C voltage for biasing its grid. Many experimenters have worked on the problem for many years in effort to produce a tube which would operate satisfactory when its filament was energized by alternating current instead of d.c. It has always been a major problem, and even to-day is far from being solved, regardless of what the average broadcast listener may think.

The trouble, and there has been much of it too, during our short experience with a.c. tube sets is that set owners simply demanded such receivers a little early; this growth should have been gradual, and not the overnight demands such as we have all seen. Radio haste always makes waste.

201-A and 199 types of receiving tubes require direct current for heating their filaments and may be considered standard because their efficiency and operating characteristics have been generally accepted through almost five years of usage. These are excellent tubes and give faithful service for better than 1000 hours of life—a feature in which a.c. tubes in most cases have fallen down badly. [The rumored short life of a.c. type tubes may be due more to excessive line voltage which causes the tubes to be supplied with filament voltages above normal than to defects in the tube itself. It is interesting to note that at least one maker of a.c. filament transformers has reduced the rated output voltage from 2.5 volts to 2.25.—*Editor.*] It is important, too, to note that 201-A and 199 type tubes cost less than the present a.c. varieties.

A COMPLETELY ELECTRIFIED 201-A RECEIVER

FROM the above remarks it is quite apparent that the only real difference as far as the user is concerned, between a.c. and 201-A or 199 type tubes lies in the method of energizing their filaments—one employs so-called "raw" a.c. house lighting current and the other pure direct current.

In the last analysis it is the A storage or dry battery which is the real bone of contention. How the use of these batteries, and also other substitutes such as electrolytic rectifiers, chargers and trickle-chargers, can be avoided is described in this article.

This unit consists of a unique dry or "electronic" full-wave rectifier for converting the house current into a pulsating direct current. The latter is then filtered in quite the usual way by means of heavy choke coils and a condenser network. The A-filter condenser, like the rectifier, is also of novel design. The condenser is bone dry and has a capacity of approximately 1500 to 2500 mfd. stored in a space of but 2 x 2 x 7 inches.

For a description of this unit, which is the Knapp A-power unit the reader is referred to the March, 1928, issue of RADIO BROADCAST.

In view of the excellent results obtained through the use of the latter equipment, and also considering (1) its low first cost, (2) cheapness of operation, (3) complete elimination of both storage battery and charger, and (4) faithful radio service at all times, it was decided to incorporate the Knapp unit together with a B and C power unit and also a one-stage audio amplifier as an integral assembly. The power unit and amplifier were mounted in the smallest possible space so that it could operate efficiently any type of receiver, such as the Atwater Kent, Crosley, Freshman, Fada, Grebe, or home-constructed receivers such as the Browning-Drake, Universal, etc.

In its final form this unit as shown in the illustrations occupies a space of 12 x 17 inches. It will supply A power for all receivers up to 10 tubes, and also B voltages up to 180 or 200 volts, in addition to a C bias voltage of 40 for its own amplifier stage.

NOT A RECEIVER WIRE OR TUBE CHANGED

NOT a wire of the receiver proper need be changed. Simply connect cable leads from the receiver which ran to the storage and B batteries over to this device. And by means of a Thordarson plug connector fitting into the old last audio stage tube socket, the latter becomes automatically replaced with a modern and up-to-date last stage audio amplifier.

This feature is most important to users of factory-made sets. Many of these do not permit operation of a last-stage power tube, either because the output tube does not employ a C battery or because the latter is in common to both audio stages, a system found in many Atwater Kent and Crosley models.

ASSEMBLING THE ELECTRIFIED PACK

A KNAPP A-Power unit may be assembled from a kit of parts or it can be purchased fully assembled; the latter arrangement is probably the better to follow for those who are not familiar with or do not care to make up the kit.

Since the Knapp steel casing measures $8\frac{1}{2}$ x 12 inches, the last dimension determines one side of the general mounting board. The writer found that a standard 12 x 17-inch drafting board, which can be obtained from any stationer, is strong, and saves all wood-working time.

For the B-supply section of the pack a simple and efficient type of B power circuit was adopted. In view of the well-designed transformer and choke coil arrangement put out by Thordarson their standard R-171 Power Compact was employed.

The steel housing of the R-171 unit encloses the transformer, choke coils and buffer condensers for the Raytheon type BH rectifier tubes.

It is important that a well built and sturdy filter condenser block be installed. A standard Dubilier type PL-574 power block condenser was used.

By means of a Thordarson type R-508-1 wire-wound resistor, B voltages of 45, 90 and 135 volts become available for the radio-frequency, detector, and audio circuits of the receiver. This resistor also supplies a 40-volt C bias potential for the CX-371-A power tube. A Dubilier type 907 1-mfd. by-pass condenser, C_6, is connected

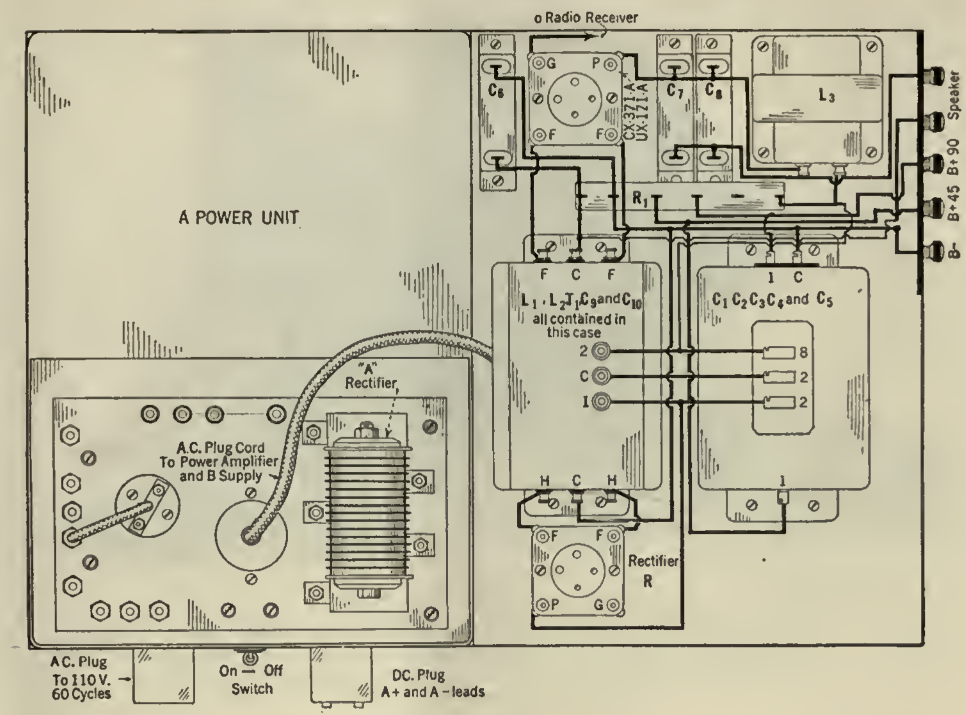


FIG. 2. HOW THE APPARATUS IS ARRANGED AND WIRED

This picture-diagram shows clearly how to place the apparatus on the baseboard and how it should be wired. The power lead from the power transformer used in the B-supply is plugged into the socket on top of the A-power unit. The entire unit is then controlled by the small toggle switch on the A-power unit

across the C bias end of resistor, as shown in Fig. 1.

A CX-371-A tube is employed in the output stage. Its filament is operated by means of a.c. supplied directly from the Thordarson R-171 transformer. A standard choke coil and condenser is also required for keeping the high voltage d.c. out of the loud speaker. A Thordarson R-196 choke coil together with two Dubilier type 907 1-mfd. condensers make up this arrangement.

To the grid terminal of the power stage tube socket connect a Thordarson R-172 power input plug. This plug is merely inserted in the second audio stage of the receiver proper and in the same manner as a tube; it transfers the first stage audio output directly to the power amplifier in this unit.

The illustrations show just where each component is placed. Fig. 2 combines suggestions on how to dispose the various parts and a wiring diagram in picture form for those who prefer to follow this kind of diagram.

THE LIST OF PARTS

THE following parts were used in the unit assembled by the writer. Parts mechanically and electrically equivalent to those mentioned below may of course be used.

L_1, L_2 Filter Choke Coils.
T Power Transformer.
C_9, C_{10} 0.1-Mfd. Buffer Condensers.

All contained in the Thordarson Power Compact R-171.

L_3 Output Choke, Thordarson Type 196.
C_1 2-Mfd. 600-Volt Filter Condenser.
C_2 2-Mfd. 400-Volt Filter Condenser.
C_3 8-Mfd. 400-Volt Filter Condenser.
C_4 1-Mfd. 400-Volt Bypass Condenser.
C_5 1-Mfd. 400-Volt Bypass Condenser.

All contained in the Dubilier Condenser Block Type PL-574.

C_6 1-Mfd. 160-Volt Bypass Condenser, Dubilier Type 907.
R_1 Voltage-Dividing Resistor, Thordarson Type R-508-1.
C_7, C_8 1-Mfd. 160-Volt Bypass Condenser, Dubilier Type 907.
Two Benjamin Sockets.
One Roll Belden Colorubber Hook-up Wire.
One Power Input Plug, Thordarson Type R-172.
Five Binding Posts.
One Kit of Parts, or Completely Assembled Knapp A-Power Unit.
One Baseboard 12×17 inches.

The following tubes are required:

One Raytheon BH Type Rectifier
One CX-371-A Power Amplifier

The writer feels that this A-B-C-Power unit and amplifier possesses many excellent features. Its total cost is quite small considering its general utility and large improvement over battery-operated equipment; further, it is thoroughly dependable in operation and the unit makes it possible for any radio constructor to realize full set electrification of all existing battery-operated receivers.

Fig. 1. READY FOR ANY TEST
This compact tester combines the functions which once required the use of a varied array of meters and testing equipment. It is adapted for continuity tests on all the circuits of a. c. or d. c. sets, filament, plate and grid voltage test, and individual tests on tubes.

A Universal Set and Tube Tester

By D. A. R. MESSENGER

I AM a radiotrician practicing general servicing, repairing and installation of all types of radio receivers.

Given a couple of meters, some knowledge of the subject and some common sense, the testing of the older types of battery receivers and tubes was a fairly simple matter. But when all types of A, B and C voltage-supply devices and, later, when the new a.c. sets and tubes came on the market, the matter of testing and trouble-shooting became something else again.

In order to eliminate the necessity for a multiplicity of meters and other accessories, I devised an instrument that, used properly, would enable me to make all routine tests on all types of receivers, both a.c. and d.c. At the time, I could find nothing on the market which answered my requirements, so I designed and built such a tester, which is herewith described.

The tester will assist in making the following routine tests:

(a). Continuity of plate circuit.
(b). Continuity of grid circuit.
(c). Continuity of filament circuit.
(d). Voltage applied to plates of tubes.
(e). Voltage applied to filaments of tubes.
(f). Voltage applied to grids of tubes in some sets.
(g). Each tube in receiver.
(h). Milliampere drain of each tube and of the whole set.

The actual construction of the tester is simple enough if you consult the accompanying photographs and wiring diagram. The paragraphs which follow may be useful to other service men and to those who wish to duplicate this unit.

THE writer of this article, who is a service man in Washington, D. C., describes in straightforward style the assembly and use of a universal set tester. This useful instrument was designed especially for routine service work. With it all manner of tests on d.c. and a.c. radio receivers are possible. The various tubes in the set can be tested, and the voltage of batteries or B-power units can be determined. This universal tester should be the service man's most useful tool, but it should also appeal to home experimenters who want to add an inexpensive and useful test set to their home laboratory equipment.

—THE EDITOR.

PREPARING THE PANEL

THE panel is drilled for the meters by scribing on the reverse side a circle which has a diameter the same as that of the meter, and drilling around this circle with a ⅛″ drill, making each drilling as close to the previous one as possible. When you have drilled the complete circle, break out the center and finish the rough edge with a small half-round file. The Benjamin socket is mounted by scribing a square 1⅝″ on a side. Drill a $\frac{3}{16}$″ hole in each corner, and a 1″ hole in the exact center. The switches are mounted in $\frac{7}{16}$″ holes, and the tip jacks in $\frac{5}{16}$″ or ⅜″ holes.

Lay out instruments on the panel in such a manner that the completed tester will present a neat and symmetrical appearance. The illustrations may be of some assistance in this respect.

Care must be exercised in wiring so that no exposed wire can come in contact with any other wire or any of the jacks, switches or measuring instruments.

The C battery can be fastened in the bottom of the cabinet with a couple of small brackets or strips of thin brass or aluminum. The cable is soldered into the circuit and the free end brought out through the same hole that was provided for the old cable from the Radiola 111. The cabinet from this receiver served nicely to house the apparatus for this tester. Those who do not find such a cabinet can house this unit in any similar cabinet which, if desirable, can be home made.

MAKING THE TESTING PLUG

THE testing plug is made up as follows: Drill a ⅜″ hole lengthwise through the center of the 1″ × 3″ piece of wood. Round one end off to make a convenient handle and taper the other end slightly to make a snug fit in a UX-199 tube base. Clean the old glue thoroughly from the inside of the tube base and melt the solder from the prongs. It may be necessary to drill out the center of the prongs with a $\frac{1}{16}$″ drill. Pass the cable through the handle and strip the insulation for about an inch from the end of each of the four wires. Connection to the tube base is made by passing each wire in turn through the proper prong (from the inside—with reference to the bakelite collar) and soldering in place. Make nicely rounded ends with the solder or you will have difficulty getting the plug into a socket later. The wood handle is now pushed into the tube base as far as possible and glued in place.

Now prepare the UY-227-to-UX adapter by soldering a phone tip to the end of each of the rubber-covered filament leads. Do not cut these leads short, for they should be long enough to reach from the tester box to any set which may be tested.

Now prepare the UY-227 tube base as you did the UX-199 base. Take one of the UX-to-UV-199 adapters and break off the bakelite from the lower part. The section which makes contact with the socket prongs is a separate piece and has four brass studs riveted to it. Cut each of these studs off to about ¼″ long. Solder a short piece of bare flexible wire to each stud. Slip a piece of spaghetti ¾″ long over each of these four wires. Then pass each wire through the proper prong in the UY-227 tube base, that is, the wire from the plate opening of the adapter through the plate prong, etc. Leave the cathode prong

open, as it is not used. Push the upper part of the adapter into the tube base as far as possible and glue in place. Solder the ends of the wires to the prongs, leaving rounded ends as before. Now solder a phone tip to each end of the 5-foot flexible rubber-covered wires.

You should now have a tester completely wired with a cable and plug attached, two flexible rubber-covered leads with phone tips on each of the four ends, one UY-227-to-UX adapter with phone tips on the filament leads and one UX-to-UY-227 adapter, in addition to the five other adapters named in the list of parts. The panel layout of apparatus is shown in Fig. 3 and the complete apparatus, tester and adapters in Fig. 1.

FUNCTION OF THE VARIOUS PARTS

THE d.c. voltmeter is for indicating the filament voltage in d.c. sets and the plate voltage and grid voltage in any set. The a.c. voltmeter is for indicating filament voltages in a.c. sets and power amplifiers. The switch, S_3, is for connecting the proper filament meter into the circuit. The push button on the d.c. meter must be depressed to read plate voltage. The d.c. milliammeter is for indicating the plate current of the tube being tested, and in conjunction with switches, S_1 and S_2, for testing tubes. With S_2 on "Test" and S_1 on "C—," a bias of 4½ volts negative is put on the grid of the tube with respect to the negative leg of the filament. With S_1 on "C+," a bias of zero is put on the grid. With S_2 on "Set," the grid of the tube is connected through the cable to the set. The switch, S_4, is for reversing the d.c. filament voltmeter in the filament circuit to conform to different methods of wiring the filaments in receivers with respect to polarity. If this provision were not made, the meter would read backward in some sockets. The switch, S_5, is for switching the d.c. filament meter from the filament circuit to the grid circuit for testing. Switches S_4 and S_5 are on the cabinet as shown in Fig. 1; S_1, S_2, S_3 are on the panel. The cable and plug with its wooden handle is for plugging into the sockets of the receiver. The various adapters provided make possible the testing of any and all types of receivers, a.c. and d.c., old or new. The two flexible leads are for connecting to the a.c. and plate voltmeter meters for external tests by means of the tip jacks or binding posts provided. In my model no jacks have been provided for the d.c. filament meter because the a.c. meter gives an indication on d.c. although it does not indicate polarity. The socket is for inserting the tube to be tested. The UY-227-to-UX, WD-11-to-UV standard and the UV-199-to-UX standard adapters are for adapting any type of tube to the UX socket. The two filament leads from the UY-227 adapter are plugged into the tip jacks connected to the a.c. meter when testing UY-227 tubes. The Benjamin socket will accommodate the short prongs of UV tubes and adapters.

METHOD OF TESTING D.C. SETS AND TUBES

HAVE set to be tested connected up and turned on as for operating. Take out first tube in the set and insert plug of tester in its place, using one of the adapters provided if necessary. Throw switch, S_3, to "d.c.," switch, S_5, to "A," and switch, S_2, to "SET." Read filament voltage from d.c. voltmeter, making adjustment of filament rheostat in set, if necessary to obtain proper voltage for type of tubes in set; that is, 5 volts for 201-A tubes or 3 volts for 199's. If the meter tends to read backward, reverse the polarity by throwing switch, S_4, until the meter reads correctly. If no reading is obtained, see that the A battery is charged and that the leads are making proper contact, both at battery and set. If no reading is now obtained there is an open circuit in the filament circuit. Try another socket and if the same result is had you are safe in assuming that either the battery switch, the rheostat or one of the main filament leads are open. Short-circuit each one in turn to locate open portion of circuit. When found the remedy is obvious. If no reading is obtained in only one socket, it may be that the socket springs are either dirty or are not in the proper position to make contact with prong of tube or adapter, or one of the filament leads to the socket is broken or disconnected, or there may be a high resistance joint in the circuit wiring. Check each item in turn until the fault is located, and then remedy. This must be done before going forward with further tests. If the voltage indicated is excessive there is either a short circuit or wrong connection indicated. Check connections to batteries or power units. After making certain that the filament circuit and voltage is correct, depress d.c. voltmeter button and read the plate voltage. If the voltage indicated is incorrect for the socket being tested, that is, 45 volts for the detector or 90 for a radio-frequency amplifier, adjust, after making certain the voltage source is connected and functioning correctly. (The two flexible leads can be plugged into the d.c. voltmeter jacks shown in Fig. 3 and used to test either batteries or power unit, keeping button depressed while using. Pull plug out of set while making this test). If no reading is obtained with the plug in the set and meter button depressed, it indicates an open circuit in the plate circuit. Short each portion of the circuit, such as the primary of a transformer or a radio-frequency coil and any stabilizing or volume control resistances which may be in the plate circuit. When the defect is located, remedy either by replacing or repairing defective part. The resistance of audio-transformer primaries, etc., must be taken into consideration when computing voltages. After making certain that the plate circuit and voltages are correct, throw switch, S_5, to "C." The grid bias voltage, if any, should now be indicated on the d.c. voltmeter. If no reading is obtained, reverse switch, S_4. If the detector socket is being tested, it will be necessary to short-circuit the grid leak and condenser with a small clip or piece of wire. Watch your meter closely as there may be a deflection of only a small fraction of a volt, depending on how much resistance and C-bias there is in the grid circuit. As this test is for continuity of circuit and not for accuracy of grid voltage, any deflection of the meter should be an indication that grid circuit is correct. Defects are located and remedied in the same manner as for the plate circuit. Check each socket in the set for these values in the same manner.

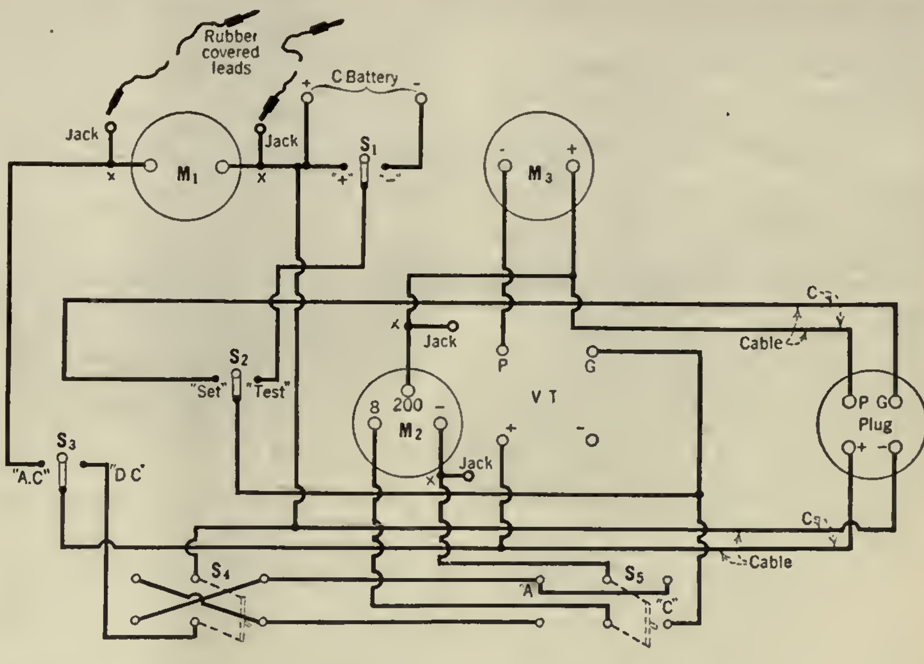


FIG. 2

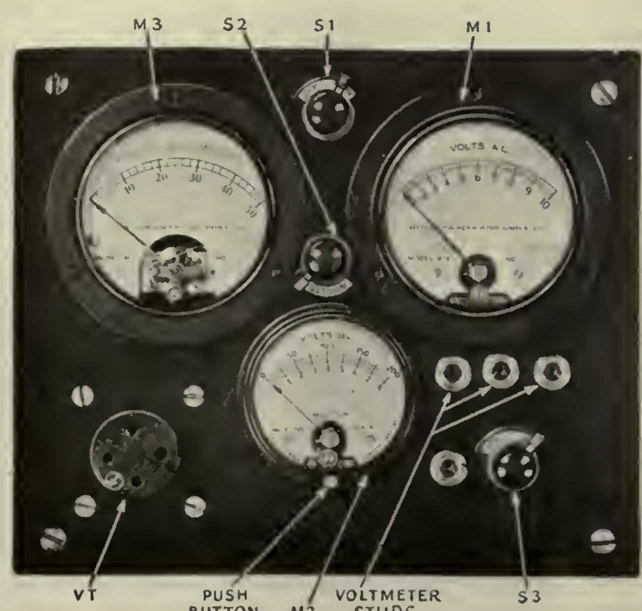


FIG. 3

TESTS FOR TUBES

AFTER making certain that filament, plate and grid circuits are correct, you are ready to test the tubes. Insert the plug of the tester into a socket in the set having a relatively high plate voltage (90 volts is best) and adjust filament and plate voltages to proper values. Now insert the tube to be tested in the socket of the tester, using one of the adapters provided, if necessary. With switch, S_2, on "TEST" and S_1 on "C—," read milliammeter and make note of plate current. Throw S_1 to "C+" and make note of the plate current. The difference in the two readings shows the worth of the tube when compared with a known good tube. Suppose the good tube (a 201-A) gives a reading of 8 mils with switch, S_1, on "C+," and a reading of $4\frac{1}{2}$ mils with switch, S_1, on "C—," the difference is $8 - 4\frac{1}{2}$ or 3 mils, a very good reading at 90 volts plate potential. If the tube being tested gives a reading of $7\frac{1}{2}$ mils with switch, S_1, on "C+" and 4 mils with switch, S_1, on "C—," the difference would still be $3\frac{1}{2}$ mils showing the tube to be at least almost as good as the sample tube. If the difference was only 3 mils the tube could be rated as only fair and should be reactivated. These sample readings are given only to make the method of testing clear and not to indicate readings which should always be found. Test each tube in turn, replacing or reactivating all those not up to the proper standard of performance. Gaseous detector tubes are very deceptive when tested in this manner, a tube of very poor quality often giving a good reading. This is due to the high conductivity of the gas in the tube. The only sure test is to replace the tube with a new one and note results. A shorted tube, that is, one with either of the three elements touching either one of the other elements in the tube, will cause the pointer of the milliammeter to be deflected off or nearly off the scale, and must be removed from tester at once to prevent damage to the meters.

The method of using the tester on a.c. sets is the same as for d.c. sets except that switch, S_3, should be on "AC" and the switch, S_4, is not used because a.c. meters have no polarity. The rules for testing apply to a.c. tubes as well as d.c. tubes. Many other uses will be found for this tester by the practical radiotrician, such as testing the filament voltage applied to rectifier tubes in B-power units. Used correctly this instrument will prove its worth many times over and will save many a weary hour over a shop bench.

The manufacturer's name and model of the various parts listed below are given merely as a guide, and not because they must be used. The experienced constructor will of course use his own judgment as to the make and model of parts he prefers. The Weston No. 506 voltmeter has an internal resistance of about 125 ohms per volt. I prefer such an instrument, rather than the more expensive 1000-ohm models, for testing B-power units because the milliampere drain more nearly matches that of a tube, giving, in my estimation, a more accurate reading for my purpose. A valuable accessory would be a Weston No. 528 a.c. voltmeter, although this is not a necessity.

PARTS EMPLOYED

THE parts and instruments used in the model described are comparatively inexpensive, and are listed as follows:

- M_1 1 a.c. voltmeter 0–10 volts, Weston No. 476
- M_2 1 d.c. voltmeter 0–8–200 volts, Weston No. 506 with 3 studs and push button.
- M_3 1 d.c. Millimeter 0–50 mils, Weston No. 301.
- S_4, S_5 2—Double-pole double-throw panel switches, Yaxley No. 60.
- S_1, S_2, S_3 3—Single-pole double-throw panel switches, Yaxley No. 30.
- 1—UX socket, Benjamin.
- 4—Tip jacks or binding posts.
- 1—Cabinet from old Radiola III.
- 1—Bakelite panel to fit cabinet.
- 1—25-ft. roll flexible Celatsite.
- 1—$4\frac{1}{2}$-volt C battery.
- 1—4-wire cable 4 ft. long. The cable used by the writer came from an old Radiola balanced amplifier.
- 1—Piece wood 1-inch diameter and 3 inches long for handle of plug.
- 1—UX-199 tube base with bakelite and prongs intact for base of plug.
- 1—UY-227 tube base with bakelite and prongs intact for adapter.
- 2—Rubber-covered flexible wire leads about 5 ft. long.
- 6—Phone tips.
- 2—UX-to-UV-199 adapters.
- 1—UX-to-UV standard adapter.
- 1—UY-227-to-UV adapter.
- 1—UX-to-WD-11 adapter.
- 1 WD-11-to-UV standard adapter.

Broadcast Station Calls With a Past

By WILLIAM FENWICK

THROUGH the years that broadcasting has been with us, the listener has interested himself, among a multitude of other things connected with a station, in the biography of practically every member of the personnel and the contributing performers. Occasionally, in the beginning of radio the former rôles the transmitter and other instruments had played elsewhere were disclosed and eagerly absorbed by the radio devotee, but this ceased as the practice came into being of making the radio broadcasting equipment to order. Few, though, have ever paused to think of what might have been the past of their favorite station's call letters, a reflection, as will be seen, that revives the memory of many heroic deeds and horrible occurrences.

WSB TWICE WRECKED

A SEARCH through old records will bring to light several calls now popular in broadcasting that once were well known in shipping circles, the original owners of many of which have met with disaster. The reason the greater number of these were not reassigned to other vessels is due mainly to a seamen's superstition that is at variance with the idea. WGR, as an instance, was at one time a familiar steamship call all along the Pacific coast when it was being used by the passenger steamer *Governor* previous to its allocation to the widely known Buffalo broadcasting station of the Federal Radio Corporation. The *Governor* sank following its collision with the freighter *West Hartland* in April of 1921, resulting in the loss of eight lives.

Another quite famous call and one which has twice been the central factor in perilous episodes of the deep, is WSB, now of the Atlanta, Georgia, *Journal*. The S. S. *Francis H. Leggett* was the first possessor and, after foundering off the Oregon coast on September 18, 1914, taking a toll of two of the 67 lives aboard, it was reassigned to the *Firewood*, the name of which forms a grim coincidence with its fate, it being burned off Peru on December 18, 1919, with 28 persons on board, all of whom were saved.

KLZ of the Reynolds Radio Company of Denver, Colorado, presents an even more exciting life story. It belonged to the *Speedwell* in 1920 when the vessel on September 29 of that year found itself suddenly amidst the sweep of a tropieal hurricane in the Gulf of Mexico. An idea of the severity of the storm may be had from the report that upon the flashing of the SOS and the ship's position, the engine room became flooded, disabling the dynamo, and the only other source of power for the station, storage batteries, became useless when the whole afterdeck was torn off and swept away by the sea. Nine of the 25 people on board were lost in this tragedy.

The most sorrowful memories, however, lie behind the letters KRE now of the Berkeley, California, *Gazette* and formerly of the *Florence H.* which was wrecked by an internal explosion on April 17, 1918, in Quiberon Bay, taking a toll of 45 lives of the 77 present in the catastrophe. The greatest monetary waste to the sea of those mentioned was in the case of the *Princess Anne*, carrying the call KOB, subsequently given to the radio station of the State College of New Mexico. The *Princess* stranded on February 2, 1920, on Rockaway Shoals, Long Island, and though she broke in two and all of the 106 passengers and crew were saved, the cargo valued at $500,000 was practically a total loss.

Another call sign which has its past marred with tragedy is the now familiar WHN of New York City. This call was at one time assigned to the ill-fated steamer *Hanalei*. Later it was passed to the steamer *Santa Isabel*, which vessel was subsequently sold to Chile. In cases of this sort, where a ship is bought by a foreign country, the letters are changed to those given by the government having jurisdiction over the purchaser. A few other examples of this where the calls are now in use in broadcasting are: WWJ, well known as the Detroit *News*, was formerly of the steamer *Peru* which was sold to France. KLS, familiar now as the Oakland, California, station of Warner Bros., was once possessed by the steamer *Kermanshah*, transferred to Hungary. Likewise, KNX of the Los Angeles *Express* was the signal of the vessel *Susana*, which was later purchased by an Italian company.

"Our Readers Suggest—"

Checking Power Unit Voltages

MANY readers of RADIO BROADCAST have constructed socket power devices providing B and C voltages. The adjustment of the resistors in such apparatus is generally a matter of guesswork, the values being varied until the reproduction sounds about right. An accurate determination of voltage values is generally a matter of purchasing an expensive high-resistance voltmeter.

The former method is generally unsatisfactory because modern receivers are designed to operate at maximum efficiency with certain definite plate voltages.

The following paragraphs describe a simple manner of checking the voltage outputs of a power unit using parts generally on hand:

The average experimenter possesses one or two 45-volt B batteries, an ordinary voltmeter, and a pair of earphones.

The power unit and the receiver are both set in operation and rough adjustments are made by ear. Ninety volts of B battery is connected with its negative terminal to the minus post of the unit. Let us assume that we wish to adjust the 45-volt tap, supplying the detector tube, to the correct voltage. One lead from the phone should be connected to the 45-volt tap on the battery and the other should be placed on the tap of the power unit. Each time the connection is made or broken, a click will be heard in the receiver, provided the two voltages are not identical. It is therefore simply a matter of slowly adjusting the tap on the power unit until no sound is heard in the phone receiver when the circuit is made or broken, or until the click is at a minimum. Under these conditions, the voltage at that tap is exactly equal to the voltage at the battery tap. The ordinary voltmeter can be used to check the battery voltage.

The same steps are taken for the 67.5 volt and 90-volt taps. Should only one 45-volt battery be available, we simply "step up" the voltage by connecting B-minus of the battery to plus 45 of the power unit as previously determined, and then use plus 45 of the battery to adjust the 90-volt tap of the power unit.

Where small C bias voltages are obtained from the same unit through the drop in a resistance, the same method of adjustment can be used by making use of a C battery with a 3-volt and 4.5-volt tap.

W. A. GROBLI,
New York City.

STAFF COMMENT

THE arrangement suggested by Mr. Grobli is more useful as a means of checking plate voltages than for setting them at some predetermined value. It often happens that receivers operate most efficiently from socket-power plate voltages which are different from the optimum battery voltages. In the majority of instances the problem will be to determine the plate voltages applied to different portions of the receiver rather than to adjust these values to a given potential. When this is the case, a 2000-ohm potentiometer should be shunted across the B block with the lead from the telephone receiver wired to the movable arm. This will make it possible to obtain practically any voltage within the range of the battery.

"OUR Readers Suggest" is a clearing house for short radio articles. There are many interesting ideas germane to the science of radio transmission and reception that can be made clear in a concise exposition, and it is to these abbreviated notes that this department is dedicated. While many of these contributions are from the pens of professional writers and engineers, we particularly solicit short manuscripts from the average reader describing the various "kinks," radio short cuts, and economies that be necessarily runs across from time to time. A glance over this "Our Readers Suggest" will indicate the material that is acceptable.

Possible ways of improving commercial apparatus is of interest to all readers, The application of the baffle board to cone loud speakers, is a good example of this sort of article. Economy "kinks," such as the spark-plug lightning arrester, are most acceptable. And the Editor will always be glad to receive material designed to interest the experimental fan.

Photographs are especially desirable and will be paid for. Material accepted will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas.

—THE EDITOR.

A Convenient Telephone Jack Arrangement

IT IS often desirable to plug the telephone receivers into the plate circuit of the detector tube without upsetting the audio-frequency amplifier. However, most jack arrangements in the detector plate circuit open the primary of the first amplifying transformer resulting in a loud howl from the loud speaker unless the amplifying tubes are turned off.

The sketch in Fig. 1 shows a simple circuit arrangement employing a double contact jack such as the Yaxley No. 5, which short-circuits the primary of the transformer when the phones are plugged-in, preventing amplifier instability and howling. The current drain of the receiver remains practically constant regardless of whether phones or speaker are employed.

P. H. GREELY, Washington,
District of Columbia.

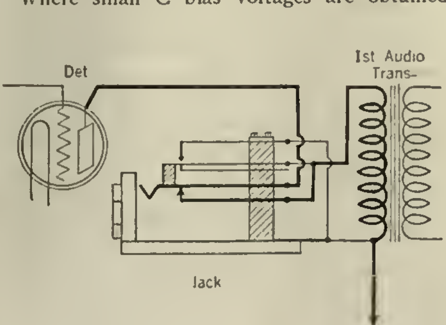


FIG. 1
The preferred jack arrangement in the plate circuit of an a.c. detector tube

Neutralizing the Short-Wave Amplifier

WHILE experimenting with radio-frequency amplifiers on waves between 15 and 200 meters, I found it next to impossible to neutralize the grid-plate capacity of the r.f. tube. I tried all of the popular circuits for neutralizing with discouraging results. I experimented with dozens of different plate coils having from one to ten turns and with different values of coupling to the detector grid coil. I finally decided to stick to one circuit and fight it to a finish. The Rice circuit was chosen. With this circuit, if the filament tap is in the exact center of the coil and the capacity of the neutralizing condenser has the same value as the grid-plate capacity of the tube, it remains neutralized regardless of the setting of the tuning condenser.

Even with this circuit I could not completely neutralize the r.f. stage although the detector and its associated parts was enclosed in a copper shielded box. I came to the conclusion that the plate coil offered too much capacity coupling to the detector grid coil. In this case an electrostatic shield would be needed to eliminate the capacity coupling. I took the primary of three turns of No. 20 d.c.c. wire as a form and wound it toroid fashion, full of No. 26 d.c.c. wire as in Fig. 2. When connected in the circuit one end of the shield winding is left open and the other was connected to the ground. It is now possible to neutralize the grid-plate capacity of the r.f. tube properly.

The same shielded plate coil was used for all

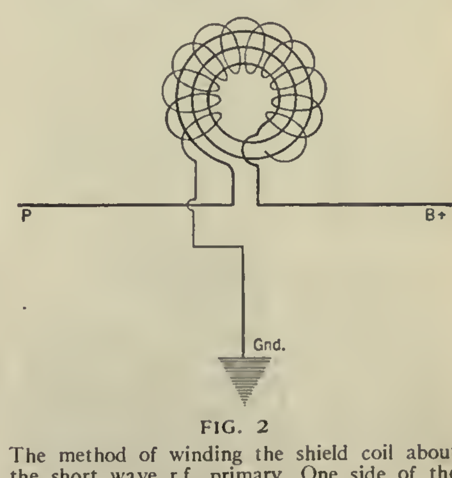


FIG. 2
The method of winding the shield coil about the short wave r.f. primary. One side of the toroidal coil is grounded

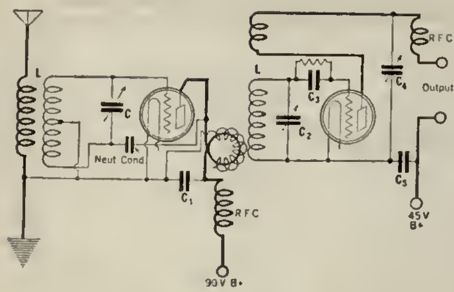


FIG. 3
The Rice short-wave receiver circuit employing the shielded coupling coil

waves between 15 and 200 meters. More than three turns would, possibly, give greater signal strength above about 75 meters. In some cases better results may be had by reversing the leads to the plate coil. Fig. 3 shows the complete circuit. The condenser "Neut. Cond." was a Silver-Marshall type 340 balancing condenser. Coils, R.F.C., are Samson r.f. chokes.

The following parts are indicated on the wiring diagram: L—Plug-in coils, C—Pacent 0.000135-mfd., C_1—Sangamo 1.0-mfd., C_2—Pacent 0.000135-mfd., C_3—0.0001-mfd. Micadon, C_4—Cardwell 0.0005-mfd., C_5— Sangamo 1.0-mfd.

Without a doubt an electro-static shield would be desirable in many broadcast receivers.

R. WM. TANNER, Berkeley, California.

STAFF COMMENT

THE problem of constructing a satisfactory short-wave r.f. amplifier involves the difficulty of obtaining stable operation. Our contributor seems to have overcome the difficulties to a satisfactory extent, although we doubt that the completed receiver is very efficient.

The problem of short-wave receiver stabilization should be relatively a simple matter using a screen-grid tube. This department will be interested in receiving data from readers who have experimented along these lines.

Wave Trap Tuned Antenna Combination

OPERATING a six-tube neutrodyne (Crosley "Bandbox") the writer is able to obtain more volume in case of weak distant stations during daytime reception by connecting in series with the outdoor antenna, 75 feet of bell wire wound on a $1\frac{1}{2}''$ cardboard tube plus a (Steinite) wave trap in parallel connection across this coil and receiver. This arrangement is sketched in Fig. 4A.

A. KLINGBEIL
Astabula, Ohio.

STAFF COMMENT

The improvement secured by Mr. Klingbeil is due to the tuning effect of the wave trap on the antenna circuit. In some cases similar results will be obtained with the very simple connection shown in B, Fig. 4.

Additional Amplification for Phonograph Pick-Up

I HAVE found that insufficient volume is obtained with the some phonograph pick-ups when using high grade low-ratio audio amplifying transformers and a low-mu power tube such as the 171 type. The conventional phonograph pick-up arrangement plugs into the detector socket, inputting the output of the pick-up into the audio amplifier. The volume can be increased by connecting the pick-up to the grid of the detector tube. Additional amplification, due to the detector, will then be obtained.

R. T. ANDERSON, Shreveport, Louisiana.

STAFF COMMENT

THERE are several ways in which this can be done, two convenient connections being shown in Fig. 5.

Drawing A shows the more simple arrangement. The plug which ordinarily is placed in the detector socket, is disconnected from the flexible braid leading to the pick-up unit. One of the two wires in the lead is connected to the grid prong on the detector socket and the other to the negative terminal on the A battery (or the negative A binding post on the set, but not to negative A on the socket).

The arrangement shown in sketch B is preferable because of the better impedance relationship between the pick-up and the input to the tube. Almost any amplifying transformer can be used at T. The pick-up wires are connected to the primary, and the secondary is wired to the detector tube—one lead to the grid prong and the other to the negative A post on the set.

A simple switching arrangement can be devised by the thoughtful user to throw the receiver from radio to phonograph pick-up.

To Stop That Whistling

IN SOME cases a receiver of the tuned radio-frequency type will cause trouble by oscillating (whistling) so badly, especially on the lower

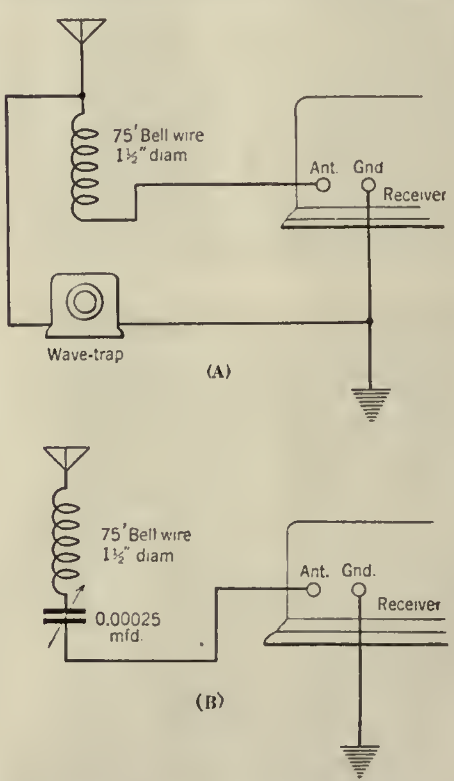


FIG. 4
Unusual wave-trap circuits which may be found effective in increasing volume on distant stations

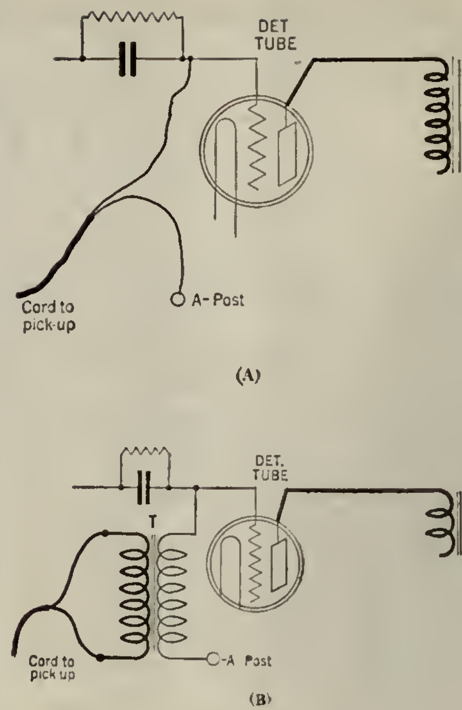


FIG. 5
Phonograph pick-up circuits utilizing the detector tube as an additional amplifier

wave bands, that it is impossible to obtain satisfactory reception of broadcast programs.

In a set having the radio-frequency transformer coils mounted directly in back of and parallel to the variable condensers, the writer recently stopped such oscillations by a very simple expedient, *i. e.*, by moving the three coils slightly closer to their respective condensers. It was really surprising how quickly the unwelcome oscillations were reduced and finally completely stopped.

This result is caused by a slight additional loss introduced in the coils due to their closer proximity to the metal end-plates of the condenser. These losses are not large enough to make any appreciable difference in the operation of the receiver, and the owner should have no qualms in applying this method. If, for some reason, it is desired to make the receiver oscillate more easily, it is only necessary to move the coils further away.

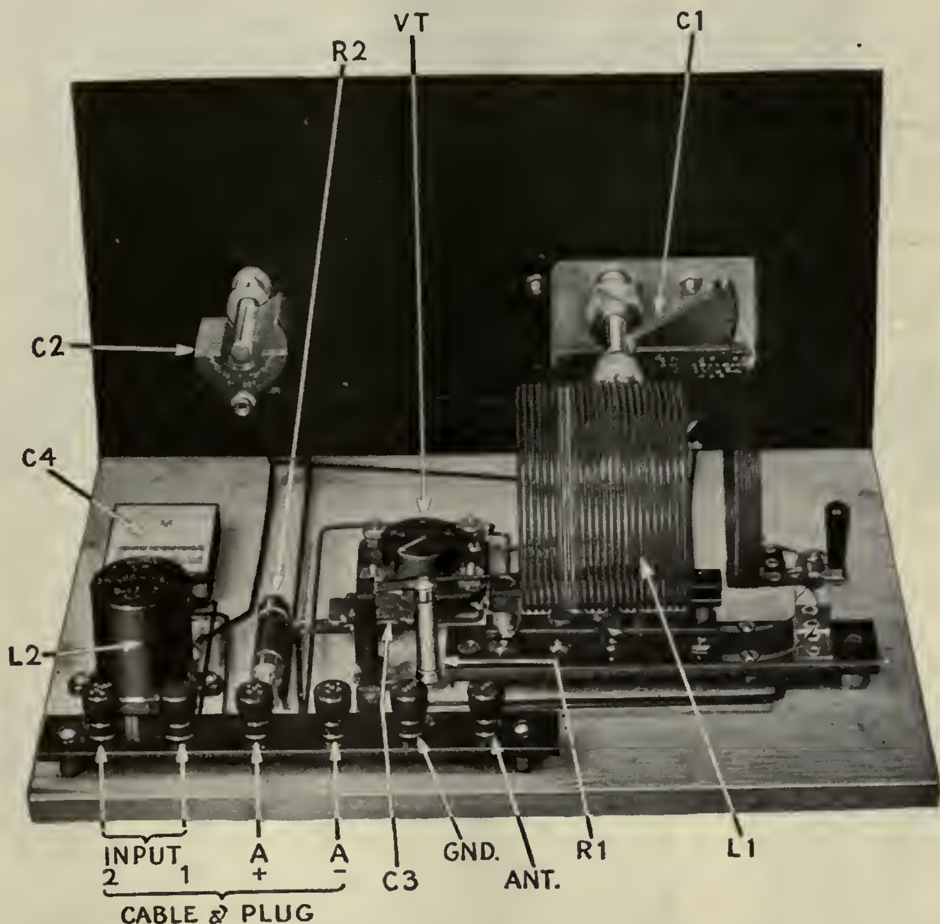
JACK L. BAKER,
Cooper, Texas.

STAFF COMMENT

IT IS not always a simple matter to affect the mechanical rearrangement suggested by our contributor. The same results can be obtained with less labor by cutting a narrow strip from a sheet of tin, brass, or copper, and bending it so that it can be clipped around one of the radio frequency coils, preferably that one preceding the detector coil. This strip should not be more than one-half inch wide and should extend only about three-quarters of the way around the coil. The degree of stabilization can be varied by changing the size of the strip. The more metal in the strip the greater will be the stabilization attained in the circuit. Many methods of stabilization are in effect "losser" systems, as is this one.

A Short-Wave Adapter For the R. B. Lab Receiver

By HUGH S. KNOWLES



FOR SHORT-WAVE RECEPTION
The layout of parts for the short-wave adapter is simplicity itself, as this photograph shows. By the use of the correct coils in the plug-in set, it makes available to the ordinary broadcast receiver the short wave-bands from about 8½ to 200 meters

IN THE article on the a.c. R. B. "Lab" receiver in the June Radio Broadcast mention was made of the fact that special provision had been made for a very valuable adjunct, namely a short-wave receiver which would extend the wavelength range of the set down to 16 meters.

The use of short waves has become increasingly important during the past few years. At first they were considered the playground of the amateur—a portion of the spectrum with which he could amuse himself without interfering with "serious" business. Since that time they have showed such promise that they are in many instances replacing long-wave communication channels.

An idea of what is being done in this respect may be gained by glancing at the list of short-wave stations published in the May Radio Broadcast, pages 44-46. This is the most complete and up-to-date list that has come to our attention.

The receiver is simplicity itself. Like nearly all of the present-day short-wave receivers it uses a straight regenerative detector with no radio-frequency amplification. This is quite satisfactory because of the hetter field strength of the short-wave stations at moderate and long distances. The factors involving the attenuation or absorption of these waves are quite complex and so far only a few generalizations have been made, although a great deal of data has been collected. It is interesting to note, however, that certain bands are valuable for daylight transmission when frequencies employed for hroadcast transmission are unsatisfactory.

THE short-wave adapter described here can be used on any broadcast receiver, a.c.- or d.c.-operated. This unit is especially designed to be used with the a.c.-operated "Lab." receiver described in our June issue by Mr. Knowles. With it you can listen in the vast range of frequencies below 200 meters. It opens the "door" of your receiver and enables you to listen-in on the thousands of stations occupying a region which no broadcast-range set can cover. It is easily possible to hear England, Holland, and—at the proper time, before daylight in the United States—Java and Australia. This is not necessarily code reception, but voice and music. This unit can be used on the "Lab" receiver, operated from a.c., but a six-volt battery must be used for the filament: if used with a d.c. set, the regular battery is pressed into additional service. Mr. Knowles is now working on a long-wave attachment for the "Lab" receiver that will broaden its usefulness in another direction.

—The Editor.

THIS UNIT CAN BE USED WITH ANY SET

ALTHOUGH the short-wave adapter described in this article was especially designed to be used in conjunction with the four-tube a.c. "Lab" receiver described in Radio Broadcast for June, 1928, this unit can be used with any receiver which now is used only for broadcast reception on the usual wave-bands. This article describes what slight circuit changes are necessary when the present short-wave adapter is plugged into the detector tube socket of the a.c. "Lab" receiver; the instructions apply also to the use of the adapter in any other a.c. operated set.

Those who have read of the experimental broadcast transmissions now being made from various stations in this country, in England, Holland, Australia and elsewhere will find the adapter described easy to build and successful in operation. [Other articles published in Radio Broadcast on short-wave receivers contain interesting and useful information about what is to be heard on these high-frequency channels. The reader is especially referred to Lieutenant

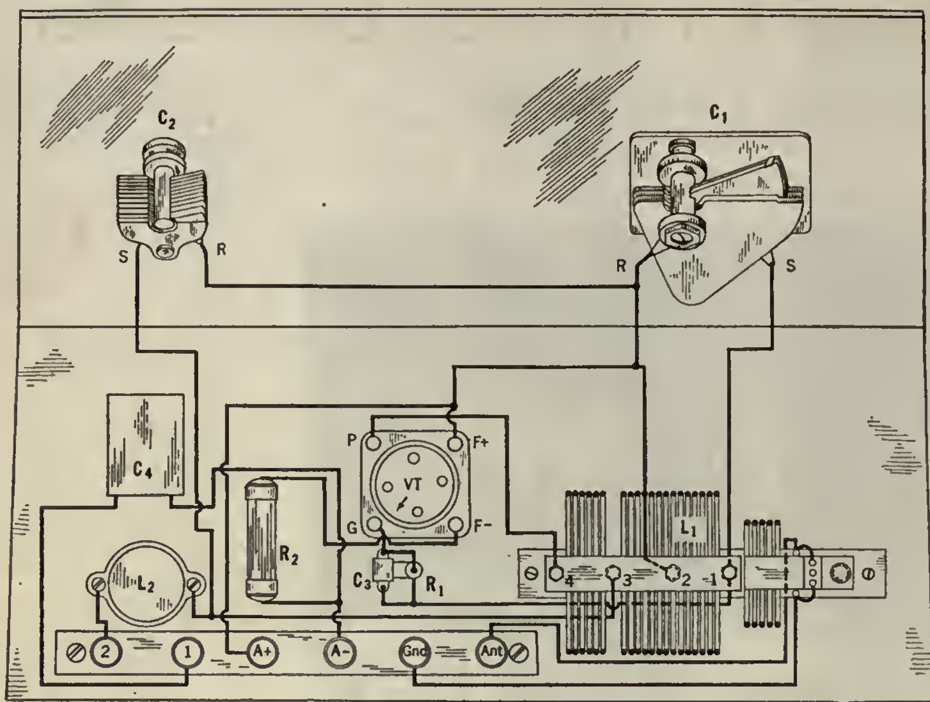


FIG. 1
A picture diagram showing exactly where the apparatus goes and how to connect it

Wenstrom's "The Cornet Multiwave Receiver" in the June RADIO BROADCAST, page 77.—*Editor*.]

A standard set of three coils used in this receiver covers the bands between 17 and 107 meters. Other coils of the same type may be secured which cover the bands from 107 to more than 200 and from about 8½ to 17 meters.

There are several respects in which the design and construction of a short-wave regenerative detector circuit differ from the type used at broadcast frequencies. The principal problems arise from the difficulty of securing good, stable regeneration at the very high frequencies, say more than 10 megacycles (less than 30 meters.)

This difficulty is due to a number of factors. To secure close tuning and more particularly to tune to the high frequencies with a reasonable value of inductance the variable capacitances must be small. This means that the stray circuit capacitance and the inter-electrode capacitances of the tube itself may be of the same order as those used in tuning.

Dielectric losses increase with the square of the frequency and these become important at high frequencies. In many cases the advantage of "debasing" the tubes lies not so much in a reduction of the inter-electrode capacity as in a decrease in the dielectric losses.

If a radio-frequency choke is to be a "universal" one it must be designed to have capacitative admittance, that is, act as a capacity at all the frequencies for which it is used. This follows from the fact that if it were inductive and used in a shunt plate-feed circuit this load would make the circuit unstable. In a short-wave receiver a tremendous frequency range must be covered and this makes it difficult to insure a high impedance at all frequencies.

Since most of the frequencies to be received are very high, a low-capacity grid-condenser may be used and a high-resistance leak is then used to increase the "time constant" of the grid-leak and condenser combination and therefore the sensitivity.

In this receiver a neutralizing condenser of the "fixed-adjustable" type is used. This has a maximum capacity of 40 mmfds. At very high frequencies, the effective input capacity of the tube which shunts the tuning condenser is high and this decreases the maximum frequency that can be received. This may be offset slightly by reducing the grid condenser capacity at these frequencies. The reason for this lies in the fact that the grid condenser and the tube capacity are in series.

The only point to watch in the construction is the mounting of the tuning condenser. The vernier dial has a sleeve which goes through the panel and this makes it necessary to mount the condenser itself on small bushings.

The layout is clearly shown in the photograph. It may be slightly improved by rotating the socket 90 degrees in a clockwise direction (when viewed from the front). Such change will make a better arrangement of the high-frequency leads which should be well separated to minimize their mutual capacity.

It is common practice to use a 250-mmfd. condenser to control regeneration. The reason for this is not quite clear since only half of the capacity is normally used. The amount of capacity necessary will vary with the layout and with the tube used but for the receiver described 100 mmfds. was found to be ample. For this reason a "midget" condenser was used resulting in a saving of several dollars. At the point where the condenser is used, that is, near maximum capacity, the rate of change of capacity per degree of rotation is lower than that for the usual logarithmic type of plate so that control is very good.

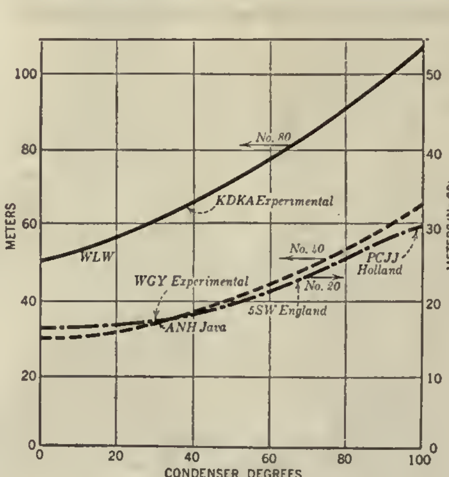


FIG. 2
Mr. Knowles's unit tunes as shown on this curve. Different tubes and slightly different wiring will naturally change these curves somewhat

THE 112A AS A DETECTOR

A 112A type tube is recommended. This has a good detection coefficient, high mutual conductance and requires no more filament current than the 201A type. It is a better oscillator even at high frequencies.

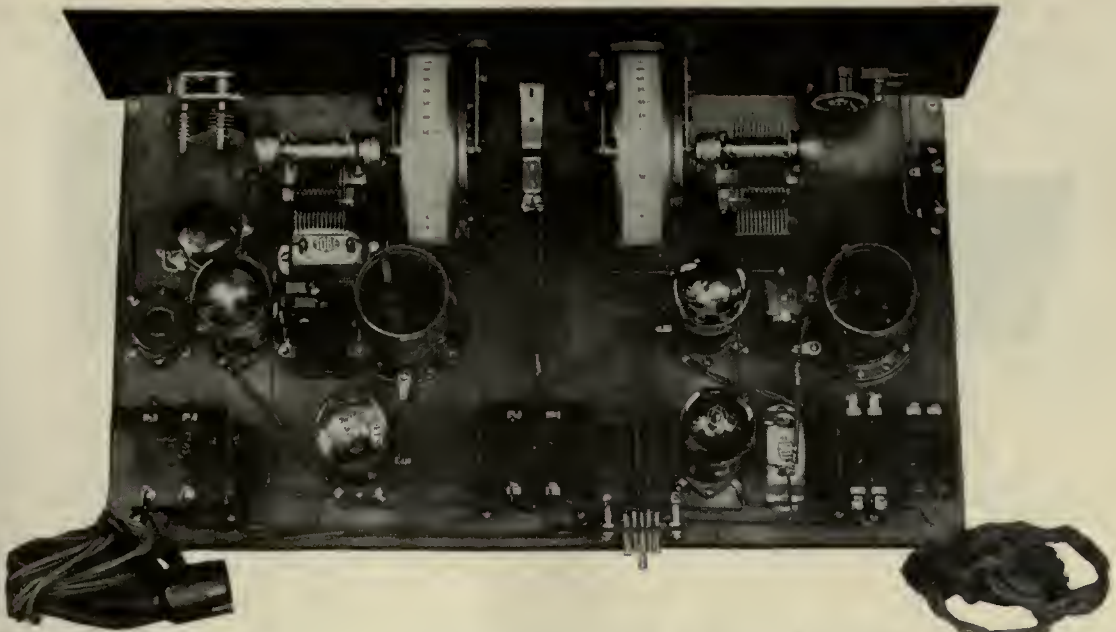
The calibration curves (Fig. 2) were made with the antenna very loosely coupled. No universal calibration curve could be plotted with close coupling since the antenna characteristics then affect the tuning. The calibration also varies slightly with different regeneration condenser settings but this is not serious. Different types of tubes also alter the calibation due to the difference in effective input capacity.

COIL DATA TABLE

Wavelength	*Sec.*	*Space*	*Tick.*	*Wire*	*Turns per inch*	*Diam.*
20	3	1	3	No. 16	10	3″
40	7	1	4	No. 16	10	3″
80	16	2	6	No. 16	10	3″
160	32	3	15	No. 20	21	3″
Primary		7 turns		No. 18	18	2½″

IN THE photograph accompanying this article, the spacing of the turns is clearly indicated. The information above is given for those who prefer to make their own coils and should be sufficient for the purpose. The copper wire used may be of any kind the builder may have at hand.

To use this set with the a.c. R. B. "Lab" receiver, the following should be done: Break the bulb and remove the elements from a UX or CX type "dud" tube. Remove the leads by heating the tips of the prongs with a soldering iron. Solder a lead to either of the large prongs. Hold the socket base in an inverted position with the large prongs, which normally go to the filament, toward you. The left hand small prong is then the one which goes to the P terminal and a lead should be connected to it. This lead is connected to the binding post which is connected to the choke, that is, post 2 on Fig. 1 and 3. The other lead goes to the binding post next to it, Post 1 on Fig. 1 and 3. If the unit is to be used with a Lab Circuit receiver whose filaments operate from batteries the posts marked A minus and A plus may be attached to leads which may be cabled with the leads from posts marked 1 and 2 and of course attached to the proper filament prongs of the plug which goes into the receiver's detector socket. Thus all connections to receiver and batteries will be made when the plug is in the correct socket. Unfortunately the a.c. tubes modulate signals too much to make it possible to use them in an oscillating receiver for code reception. With such connections utilizing the A-



THE RECEIVER FOR WHICH THE ADAPTER WAS DESIGNED

The a. c. model of the R. B. Lab. receiver, for which the short-wave adapter described in this article was especially designed, is shown above. This receiver was described in the May number of RADIO BROADCAST. As explained in the article, the adapter may be used with any other standard a.c. receiver.

battery connections of the receiver detector, the Amperite will no longer be needed and may be shorted out or left out of the assembly.

Where only broadcasting is to be received and the set is not used in an oscillating condition it is possible to use a 227 type tube. In this case a 5-prong socket is necessary and four flexible leads may be run to the receiver. Two should go from the H pins of the plug to the filament binding posts, one from the P to the B plus and another from the K to the blank binding post. The K terminal of the short-wave tube should then be grounded and the return to the receiver secured through the common ground. A 227 type amperite should be used.

For intermittent operation, 8 dry cells connected in series-parallel will give very satisfactory results with the 112A tube.

Where, because of the layout or for any other reason, there is poor regeneration on the very high frequencies, a 10,000-ohm resistor (a Durham grid leak for example) should be connected in series with the choke. This increases the impedance of this circuit at these high frequencies without introducing sufficient resistance in the circuit to lower the plate voltage appreciably. Increasing the detector plate voltage to 67.5 will result in better oscillation too. It may be thought that omitting the choke coil in the detector plate lead and substituting a fixed resistance—such as is often done in amateur code receivers—would result in as good a receiver at a reduced cost. This is true provided broadcasting is not to be received, but the 10,000-or 25,000-ohm resistance, which is often used, offers appreciable impedance to low voice frequencies in comparsion to the impedance of the audio amplifier looked at from the detector tube. This would naturally result in poor low-frequency reproduction. The choke offers sufficient impedance at all except the very high frequencies for good regeneration and has no effect on quality of reproduction.

PARTS EMPLOYED

IN THE parts list which follows, the only special parts are the coils. [For best results, the coil and the condenser used with it should be carefully chosen for in the high-frequency channels, slight differences in coil turns and condenser size—differences from those suggested here, that is—greatly affect the tuning range. In RADIO BROADCAST, June, 1928, page 78, appeared data on some short-wave coils which can be home-wound. See also, pages 13–14 of our May, 1928, issue for details of other home-made coils.—*Editor*]. Any other parts from well-known manufacturers may be used, provided their respective electrical and mechanical characteristics are similar to those given in the list.

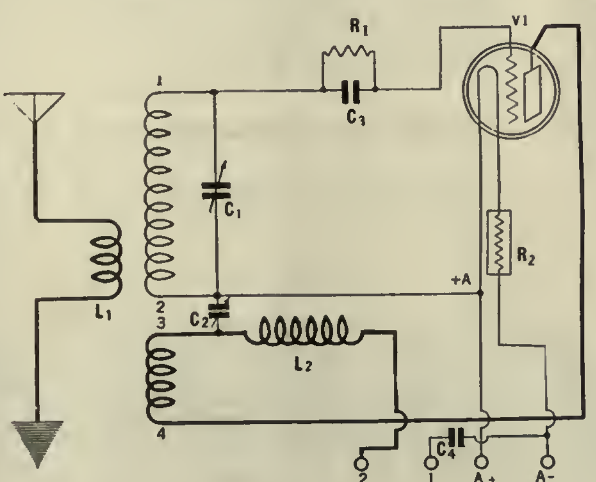


FIG. 3

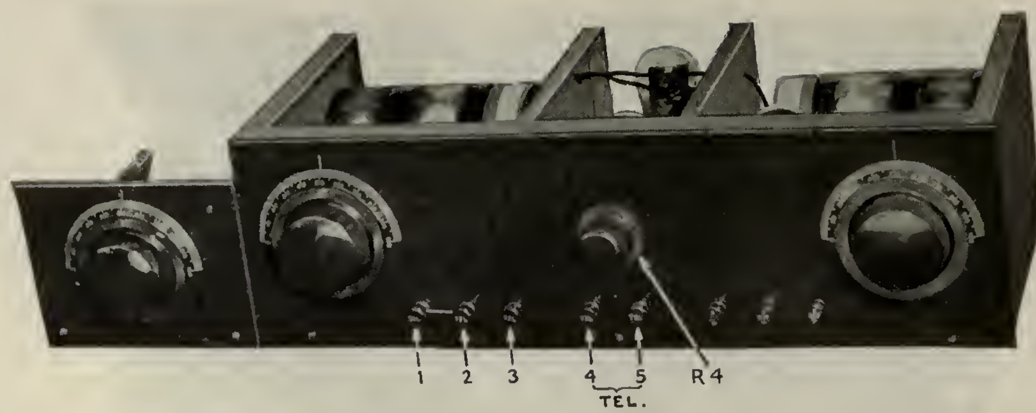
In many amateur's receivers the plate choke is connected on the plate side of the regeneration coil. Better oscillation control is obtained by placing it at the ground end of the coil, as this diagram shows

L_1	1	Set (3) Hammarlund Short-Wave Coils.
L_2	1	No. 85 Hammarlund Radio-Frequency Choke
C_1	1	.00014-Mfd. Hammarlund ML-1 Condenser
C_2	1	.0001-Mfd. Hammarlund MC-23 Condenser
C_3	1	Neutralizing Condenser—Hammarlund or Sangamo .000050-Mfd. Fixed Condenser
C_4	1	0.5-Mfd. Parvolt Series A Condenser
R_1	1	10-Megohm Durham Grid Leak
R_2	1	Amperite Type 1A
	1	Benjamin Socket
	1	Durham Grid-Leak Mount
	6	Eby Binding Posts
	1	National Velvet Vernier Dial
	1	7 x 12 x $\frac{3}{16}$ Westinghouse Micarta Panel
	1	10,000- or 25,000-ohm resistor (optional)

ACCESSORIES

1 CX-312A tube

Six-volt filament supply: storage battery or 8 dry cells.



FOR THE EXPERIMENTALLY INCLINED

A beat-frequency oscillator of the type shown here is one of the most valuable pieces of testing equipment that the home experimenter can have. This one is built entirely of standard parts, with the exception of the home-made coils, which any radio fan can make for himself. It employs two oscillating tubes, a detector and a stage of audio to raise the detector output to the desired level.

How to Build a Beat-frequency Oscillator

By G. F. LAMPKIN

COMBINING the factors of simplicity, portability, and flexibility, a beat-frequency oscillator is a most useful piece of apparatus to have in the laboratory. It utilizes, as may be known, two radio-frequency oscillators, one of which has its frequency varied so as to yield in the audio range beat frequencies with the other oscillator. A detector takes out the audio components, and amplification as desired may be used to bring up the level of their power. A range of audio frequencies of reasonable purity from 30 to 10,000 cycles may be had with adjustment of but one dial; an output of approximately 15 volts r.m.s. can be obtained using only four tubes; and finally, the output over the above mentioned range may be held constant within ten per cent. Such an oscillator was constructed by the writer for use in thesis work at the University of Cincinnati; and constructional data may be helpful to others who have use for a similar instrument.

A MOST convenient type of audio-frequency oscillator that anyone can make is what is known as a "beat to frequency" oscillator. Two radio frequencies beat together to produce an audio frequency note. This note is amplified and may be used to test loud speakers, audio-frequency amplifiers, or for bridge measurements of capacities and inductances. All frequencies from zero to 10,000 are obtainable from a single dial.

Such an oscillator is described in this article by Mr. Lampkin who is Baldwin Fellow in Electrical Engineering at the University of Cincinnati. The apparatus is such as may be found in any experimenter's laboratory: the only special part is the coil —which anyone can make.

—THE EDITOR.

The selection of the radio frequency at which the oscillators should work is made by compromise. If the frequency carrier is low, it becomes difficult to eliminate that frequency in the output of the oscillator. The resistance-coupling between detector and amplifier is capable of passing too low a carrier frequency, and the ordinary vacuum tube voltmeter is likewise capable of responding to such a frequency, so that even at zero beat between the radio-frequency oscillators, the output meter shows a deflection. Increasing the carrier frequency permits more perfect discrimination between it and the audio frequencies. On the other hand, at high carrier frequencies, the inherent coupling between the oscillators causes "pulling." This means that, as the frequency of one oscillator approaches that of the other, a point is found where the two "pull" into synchronism, and the beat note disappears. The point at which the oscillators pull into step may be as high as two or three thousand cycles—the closer the coupling the higher is this frequency.

The carrier-frequency determined for the particular oscillators was 175 kc. At this frequency, the magnitude of carrier present in the output was less than one-tenth of a volt, the lowest calibration of the vacuum-tube voltmeter that was used. Only partial shielding is necessary between the two oscillators to reduce the coupling to a point where the beat note can be lowered to 15 cycles without the occurrence of pulling. Complete shielding was provided for, however, with the idea in mind that the carrier frequency of the oscillators may be made to cover the broadcast band—by means of another coil, of course. At any particular radio frequency setting for the one oscillator, the frequency of the other is varied to either side by vernier control to yield in effect a modulated radio frequency, so that the instrument becomes a miniature broadcasting station for receiver testing. To this end, provision is made for leading out the modulated radio-frequency currents from one oscillator by means of an external coupling coil to be connected to posts 1 and 3 on Fig. 2. Provision is made also for exterior vernier control. Plug-in coils in the oscillators make it possible to cover other frequency ranges.

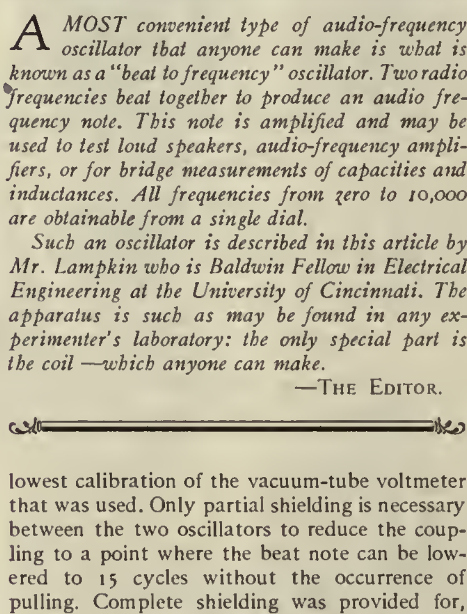


FIG. 1

Two coils of this type are used for the two oscillators. They should be made exactly alike in dimensions. The wire used in all these coils is No. 24 scc

A FOUR-TUBE UNIT IS BEST

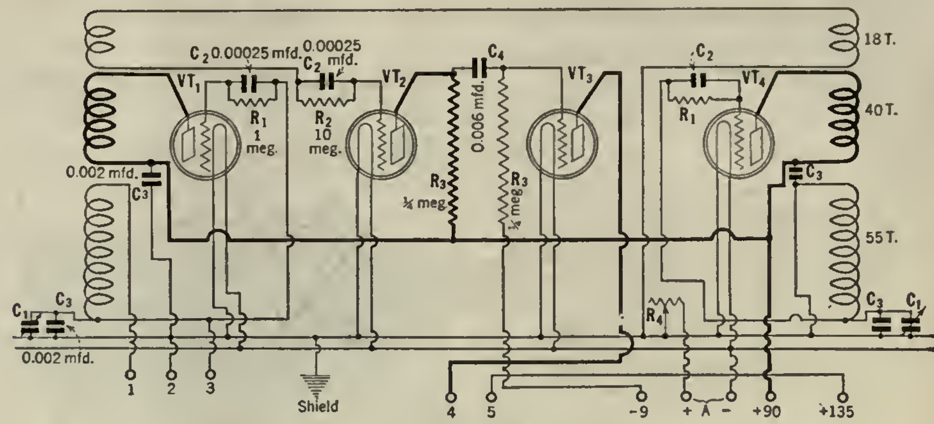
AN ATTEMPT was made to use one of the oscillators also in the rôle of detector. The beat-frequency oscillator thus used one radio-frequency oscillator, one oscillator-detector, and one amplifier. The output voltage obtained from such an instrument was comparatively low, and varied in the ratio of four to one over the 100 to 10,000 cycle range. When the circuit was reconstructed to use a separate detector, the resulting output of the device averaged three and a half times larger than before, and was approximately constant over the same frequency range as above. In point of both magnitude of output and constancy of output the inclusion of the fourth tube is well worth while. Still more tubes may be included as audio-frequency amplifiers if it is desired to raise the level of the output. However, the 15-volt output that can be obtained from four tubes is enough to give a fair output when comparing and testing loud speakers, and it easily fulfills the requirements when the user is measuring amplifiers, transformers, and similar work.

The schematic for the beat-frequency oscillator is presented in Fig. 2. The two radio-frequency oscillators are made as alike as possible so that changes in operating conditions will affect both of them simultaneously. A tickler-feed-back oscillating circuit is used; a 0.002-mfd. fixed

condenser, C_3, and the variable tuning condenser, C_1, are across only the grid coil, which allows the rotor and end plates of the variable to be grounded. The plate voltage is series-fed to the tubes. The oscillator (VT_1 in Fig. 2) has the tuned circuit opened at the filament end and brought to a binding post on the panel (No. 1 in Fig. 2) in order that the external coupling coil can be connected for the dummy transmitter use as outlined above. In normal work as a beat-frequency oscillator, terminals 1 and 2 are shorted. From the same oscillator is brought out a lead (No. 3 on Fig. 2) to a binding post where an external vernier condenser of about 70 mmfd. may be connected. The radio-frequencies from the two oscillators are combined through the 18-turn pickup coils and impressed on the detector. Resistance-coupling is used into the final amplifier tube because of its excellent response on all frequencies. The tubes used are UX-201A's for the oscillators, a UX-200A detector and a UX-112A amplifier.

The panel drilling, coil dimensions, and other constructional details are indicated in Fig. 1 and 3. An idea of the baseboard layout can be gained from the photographs. The oscillators are put at opposite ends of the panel, and the detector and amplifier occupy the smaller, 4½″ wide, compartment. The copper shielding is cut to the given sizes and the panel sheet drilled so that it is held to the panel by the apparatus. The other sections are soldered in place. The top and back sections of the shielding are used only for the miniature-transmitter function, when they are held in place by screws to the side flanges. As the filament voltages are not critical, they are all controlled by a single ten-ohm rheostat, R_4. Other binding posts on the panel are for battery-supply input, and for the audio-frequency output from the plate of the amplifier tube.

The voltage output characteristic for the finished oscillator is given in Fig. 4. It was taken for the normal operating voltages of 90 volts B supply to the oscillators and detector, 135 volts B and 9 volts C-bias on the amplifier, and filament voltage at 5. The audio-frequency output was measured with a vacuum-tube voltmeter across a 10,000-ohm resistance in the output. The B and C voltages for the amplifier tube are chosen so that at no point does it overload. The change in amplifier plate current from zero beat to full output is negligible. The output is, as may be seen, constant to within ten per cent. over the entire range from 30 to 10,000 cycles. The values of resistance R_3, given in Fig. 2 for the coupling unit, is rather important, and should be adhered to if nearly constant output is desired. For instance, when the grid leak was changed from .25 to 1 megohm, and other conditions unaltered, the output voltage at 300 cycles was 18.2 and at 10,000 cycles 10.5—a variation of over 75 per cent.



SCHEMATIC DIAGRAM

FIG. 2

Many times we have promised RADIO BROADCAST's readers an article on how to make an audio oscillator. This is the circuit—at last! It uses parts which are easily obtainable or home constructed

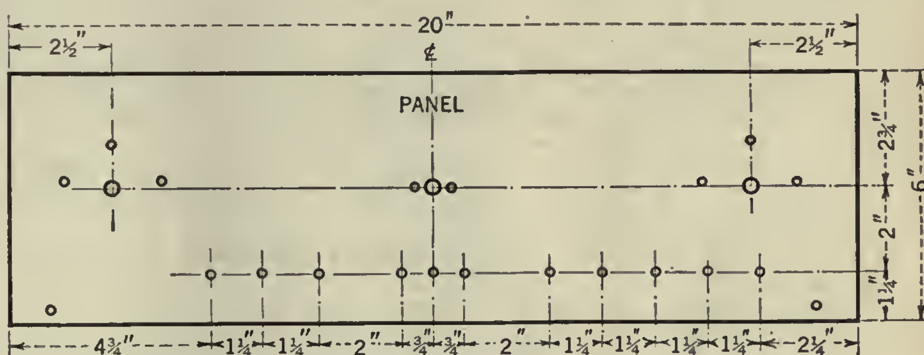
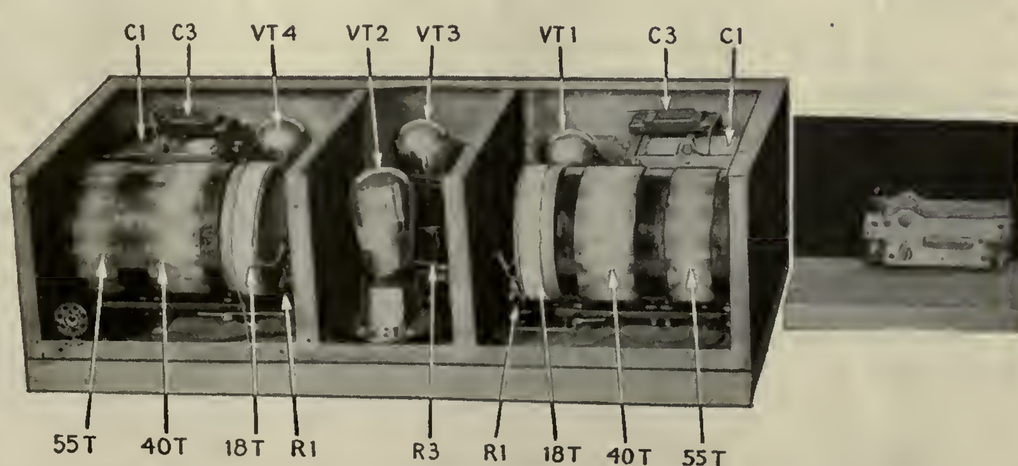


FIG. 3

The dimensions of Mr. Lampkin's oscillator panel are given here

LAYOUT OF THE APPARATUS

THE layout of the instrument calls for a Cardwell type 192E, 0.0005-mfd. maximum, taper-plate condenser for tuning each oscillator. In operation of the instrument, one condenser is set at or near zero dial reading, and the other turned to give zero beat; in other words, the second condenser is used for trimming. Then from these settings the first condenser is varied to give the beat frequencies. The beat, or audio-frequency calibration for settings of the 192E condenser is plotted in Fig. 5. This beat curve starts from zero beat at 5 on the dial. At the low end of the spectrum the calibration is rather too steep to permit of accurate setting at these frequencies. A Pilot straight-line-frequency con-



BEHIND THE PANEL

The two oscillators are at the left and right of the main panel. The detector and audio tubes are mounted in the center. The shielding panels are cut and flanged from copper plate

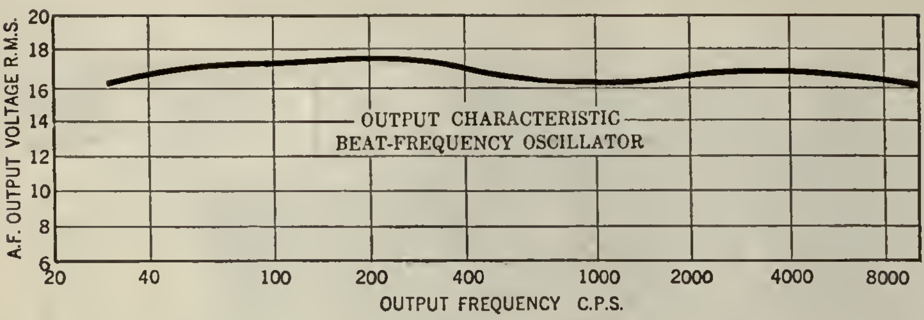


FIG. 4

This beat-frequency oscillator has a characteristic that makes measurements with it an easy matter —straight from below 40 to above 8000 cycles, and every cycle obtainable from a single dial!

denser of 70-mmfd. maximum capacity was used as an external vernier to open up the lower range, resulting in the dotted curve in Fig. 5.

The two Figures, 5, in which frequencies are plotted logarithmically and 6, in which frequencies are plotted linearly, give a comparison of the types of calibrations that may be expected for various condensers. A National 0.0003-mfd. semicircular plate—straight-line-capacity—condenser gives a frequency calibration that is linear with respect to dial reading, as in the solid curve of Fig. 6. Although the frequency of the oscillator varies inversely as the square root of the capacity, the tuning condenser is only a small portion of the total capacity in the radio-frequency circuit. Its variation swings the frequency over only a small part of the capacity-frequency curve, and to all intents the curve is linear over this small portion. Plotted also in Fig. 6, for comparison when using the linear frequency axis, are curves

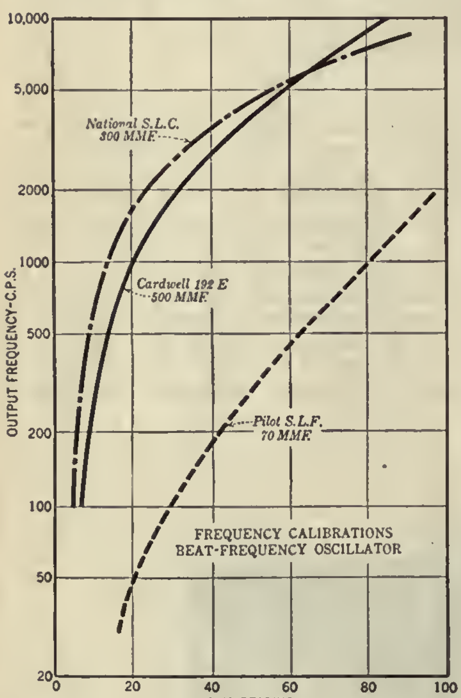


FIG. 5

The calibration curve of the oscillator can be plotted in two ways; one way is with the frequencies plotted logarithmically, or in octaves, as shown here

for the 0.0005-mfd. type 192E Cardwell and for the Pilot 0.000070-mfd. straight-line-frequency condenser which was used as an external vernier condenser. The Cardwell condensers were used in the writer's oscillator.

The frequency calibrations in all cases were made by comparing the sound output of the beat-frequency oscillator with standard frequencies from a Western Electric 8A oscillator. One pair of phones was connected to the beat-frequency instrument and another pair to the 8A oscillator. For any given setting of the standard, the beat oscillator was brought to approximately the same pitch and then tuned accurately by listening to the beats between the two sounds. As regards the purity of output, the beat-frequency oscillator seemed to be as good as the Western Electric 8A. The most distinct beats were found when the intensities of the two sources were approximately equal.

Each time the apparatus is used the variable oscillator is set at the dial setting arbitrarily chosen as zero, and zero beat obtained by varying the trimming condenser, C_1. This means that the constancy of the calibration is dependent primarily on the constancy of the tuning-condenser capacity. When a heavy condenser with substantial bearings is used for tuning, the accuracy to which the calibration may be used is limited only by the closeness to which the dial may be set. For the same reason, changes in the various operating voltages have negligible effect on the calibration; and it is not a hardship when a tube, with which the instrument was calibrated, is misplaced.

CALIBRATING WITH A PIANO

IT IS entirely possible to use a piano as a source of standard frequency when no other source is available. The range from 30 to 4096 cycles may be covered in this way. Another auxiliary audio-frequency oscillator may then be set to the piano frequencies, and harmonics of it picked out to calibrate the beat-frequency oscillator in the 4000 to 10,000-cycle range. The fundamental frequencies of the notes starting from middle C, are: C 256, D 888, E 320, F 341, G 384, A 487, B 880, and C 512. Notes an octave higher are twice the frequency of the corresponding lower note; and likewise, notes an octave low are half the frequency of the higher note. [See Laboratory Sheet No. 52, RADIO BROADCAST, Dec., 1926, for a chart of piano frequencies. —*Editor*].

The oscillator is useful for comparison by ear of loud speakers and other electro-acoustical devices. Peaks and dips in the response stand out when the input frequency is varied rapidly over the spectrum, and upper- and lower-cutoff frequencies may be approximately determined. A 10,000-ohm potentiometer, such as is used as a volume control, across the output of the oscillator allows any desired magnitude of audio-frequency voltage to be taken out for audio-transformer testing, determination of amplifier characteristics, bridge measurements, and so on.

PARTS EMPLOYED

THE parts used in the writer's oscillator follow. The parts not mentioned by name are not at all critical and any standard make may be used. The only special apparatus in the entire equipment are the coils which are described in Fig. 1

C_1 2—Cardwell 500-mmfd. taper-plate condensers type 192E
4—General Radio UX Sockets
C_2 3—0.00025-mfd. fixed condensers with grid-leak mounts
C_3 4—0.002-mfd. Sangamo fixed condensers
C_4 1—0.006-mfd. Sangamo fixed condensers.
8—General Radio No. 8745 plugs and 874P jacks
2—lengths bakelite tubing, $5\frac{1}{2}''$ x $3\frac{1}{2}''$
R_1 2—1-megohm
R_2 1—10-megohm } metallized resistors
R_3 2—0.25-megohm
R_4 1—Filament rheostat, 10-ohm
10—Binding Posts
2—Bakelite dials, 4″
Seven square feet 1-64″ copper sheet

Shielding:
Sides—4 pcs. 7″ x 10″—Turn up $\frac{1}{2}''$ flange all around
Bottom—1 pc. 10″ x 20″—Turn up $\frac{1}{2}''$ flange all around
Top—1 pc. 9″ x 20″
Front & Back—2 pcs. $5\frac{1}{4}''$ x 20″
1—Formica panel 6″ x 20″
Baseboard 9″ x 20″ x $\frac{3}{4}''$, wire, screws, etc.

The following tubes are required to put the apparatus in operation:
2 201A type for the oscillators
1 200A type for the detector
1 112A type for the amplifier

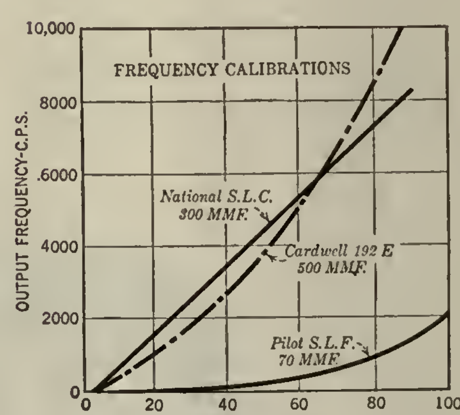


FIG. 6

The second manner of showing what frequencies the oscillator grinds out—that is, where the frequencies are plotted "straight" and not in octaves —is shown in this curve

No. 3. July, 1928.

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

The Grebe A. C. Six

THE Grebe A C Six is a six-tube receiver designed for a.c. light socket operation. By light socket operation is meant the use of a.c. tubes and the use of A B and C power units.

The receiver employs three stages of tuned radio-frequency amplification, a non-regenerative detector and two stages of transformer-coupled audio-frequency amplification. In many respects, particularly in the tuning system, this receiver is very similar to the design of the standard Synchrophase receiver. The antenna circuit is arranged for use with two lengths of antennas. The long antenna connection includes in series a capacity of .000225 mfds. The short antenna connection leads directly to the coil proper. The secondary circuit of the antenna coupler, that is, the input circuit of the first radio-frequency tube, is arranged for a tapped inductor permitting variation of the inductance tuned by the first radio-frequency condenser. In this manner it is possible to compensate the effects of various lengths of antennas and still permit accurate operation of the ganged condensers, which provide single tuning control.

The tuning system employed in the other stages is conventional and employs the peculiar method used by the engineers of the Grebe organization. Type 326 a.c. tubes are employed for the three radio-frequency stages and the first audio-frequency amplifier. A 327 type tube is employed as the detector and a 171 as the output audio tube.

A novel "local" and "distance" switch is incorporated into the set. This shunts a resistance of 170 ohms across the plate coil of the second radio-frequency transformer, thus broadening the tuning and permitting better sideband response, with consequent improvement in tone quality. For distant reception this fixed resistance is disconnected from the circuit with accompanying increase of sensitivity and selectivity. The electrical balance in the filament circuit of the four 326s is obtained by means of a variable midtapped resistance across the filament circuit. All the grid return leads in the receiver with the exception of those which convey the bias voltages are connected to ground and the midtap of this resistance is also connected to ground. Its value is 27 ohms.

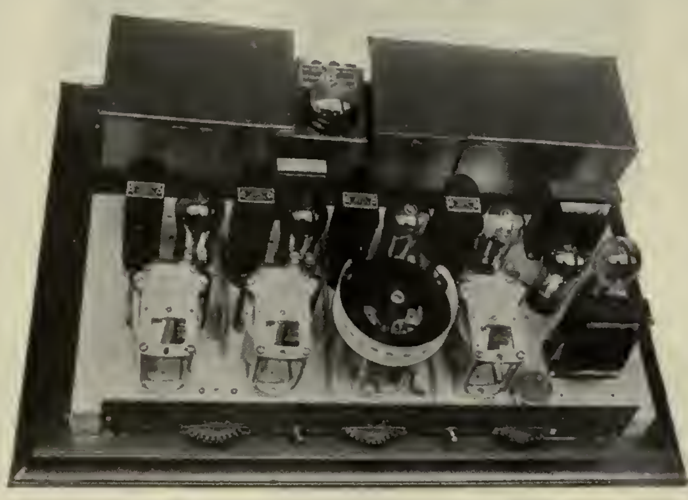
The volume control employed in the receiver is a variable resistance of 2500 ohms placed in shunt with the primary winding of the fourth tuned radio-frequency transformer. By manipulating this resistance it is possible to vary the amount of radio-frequency voltage generated across this coil and transferred to the secondary, thence onto the grid of the detector tube. By employing this arrangement, the filaments of the various tubes are not disturbed and annoyance from "hum" due to an unbalanced filament circuit is avoided.

The power pack consists of two separate transformers, one to supply the filament voltages and the other to supply the plate voltages of the tubes by means of the rectifier tube. The electrical balance of the various filament circuits, of which there are three, a 1.5- for the 326s, a 2.25-volt for the 227, and a 5-volt winding for the 171, is obtained by the use of a midtapped resistance across each filament circuit. Particular notice should be made of the fact that the 327 is now rated at 2.25 volts rather than 2.5 volts, the previous rating. This permits much longer life.

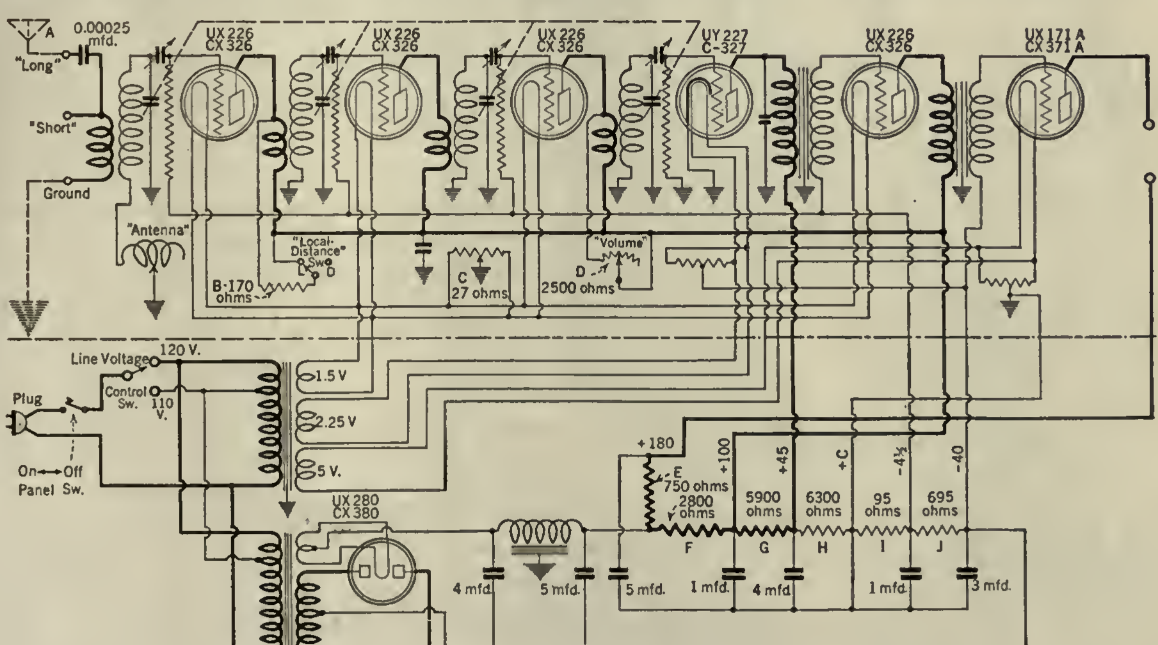
The B and C supply is obtained from a full-wave rectifying system employing a 380 tube with a single section "brute force" filter. The condensers employed in the filter are of 4 and 5 mfd. each. The voltage dividing resistance consists of six sections. One resistance E of 750 ohms reduces the eliminator voltage to the required 180 volts. Another resistance F of 2800 ohms reduces the voltage to 100 for the first audio and the three radio-frequency tube plates. Another resistance G of 5900 ohms reduces the voltage to the prescribed 45 volts. The 4.5 volts negative C bias applied to the grids of the three radio-frequency and the first audio tube is obtained by means of the voltage drop across the resistance I of 95 ohms. The grid bias for the 171 is obtained by means of the additional drop across the resistance J of 695 ohms. The receiver is a single tuning control affair with an antenna compensating control. The primary power circuit is arranged for 110 or 120 volt 60 cycle a.c. supply. The "on" and "off" switch controlling the operation of the complete receiver is located on the face of the panel, between the tuning and the volume control drums. The tuning dial is graduated in kilocycles. No method of coupling the speaker to the output tube is provided, that is to say, binding posts are provided but one should not permit the current of 20 mils to flow through the speaker. Any transformer designed for use with the 171 or any choke-condenser combination of suitable electrical values will be sufficient.

The power unit is contained within the cabinet which houses the receiver proper, but all units inclusive of the rectifier tube are contained within shields.

THE RECEIVER IN ITS CABINET



HOW THE PARTS ARE ARRANGED



CIRCUIT OF THE GREBE A. C. SIX. THE POWER UNIT IS INCLUDED

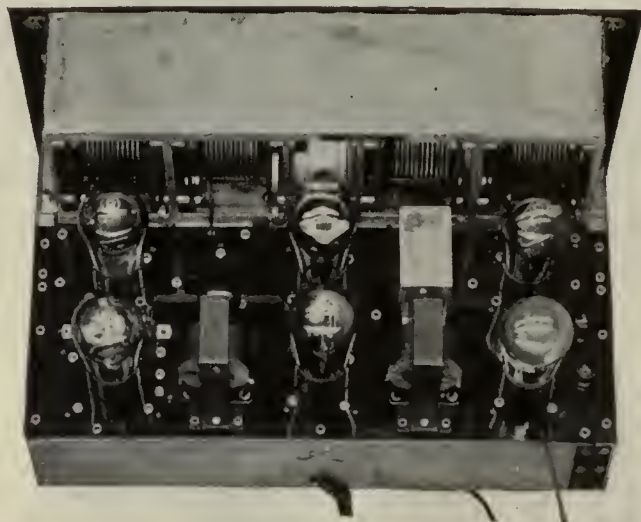
No. 4. July, 1928.

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

The Kolster 6K A. C.

THE Kolster 6K A.C. receiver is an example of conventional a.c. receiver design utilizing the standard types of a.c. tube. The receiver consists of three stages of tuned radio-frequency amplification, a non-regenerative detector and two stages of transformer-coupled audio. The tuned radio-frequency stages are of two types. The input stage consisting of a tapped primary inductance coupled to a variometer which in turn is tuned by means of a shunt variable condenser. The other three radio frequency stages are of the conventional type, utilizing fixed primary and secondary inductances and tuned by variable condensers. Stabilization of the radio-frequency system is effected by employing resistances in the grid circuits of the radio-frequency tubes. These grid suppressor resistances are of the order of 800 ohms each. The three radio-frequency and first audio tubes are CX-326. The detector is a C-327 and the second audio is a CX-371. The detector utilizes the grid condenser and leak arrangement; the grid condenser being of .00025 mfd. capacity and the grid leak of 2 megohms.

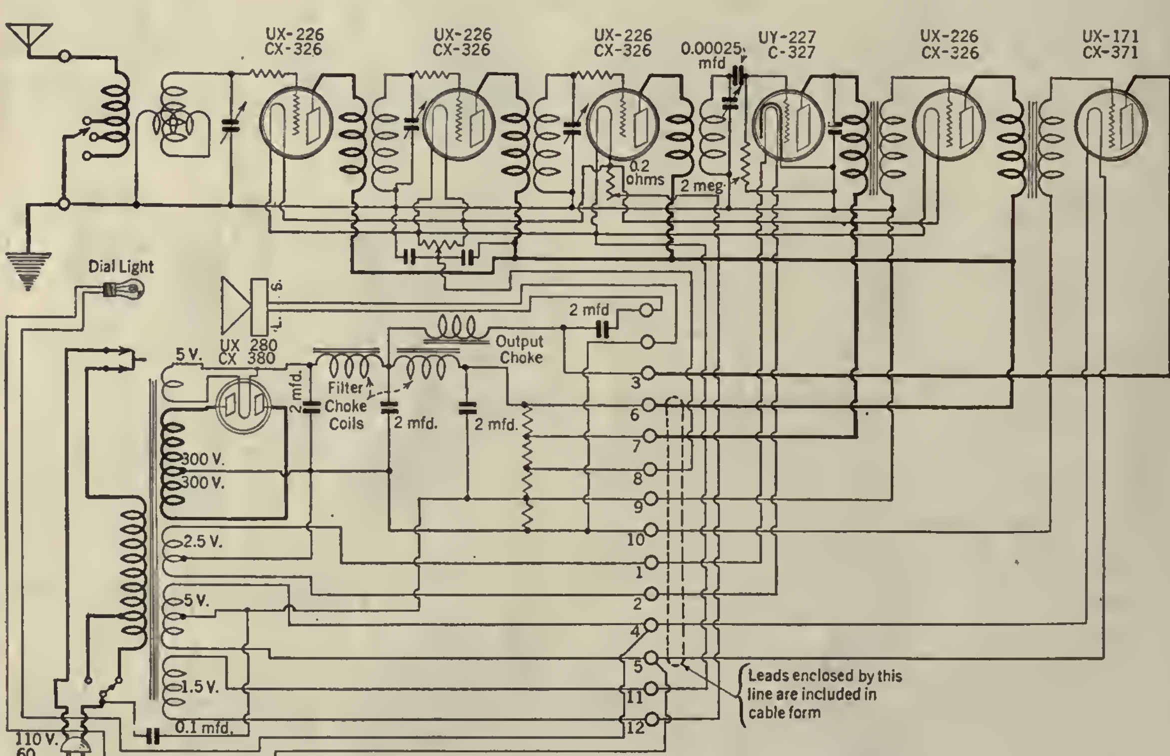
The power supply for this receiver is a full-wave rectifying system employing a CX-380 tube. The power transformer consists of five secondary windings and a tapped primary winding suitable for various line voltages operating at 60 cycles a.c. The five secondary windings supply five volts for the CX-380, 300 volts for each plate of the rectifying tube, 2½ volts for the detector, 5 volts for the CX-371 power tube, and 1½ volts for the CX-326. A center-tapped transformer winding is employed in order to obtain the electrical balance in the filament circuit of the C-327 tube. The electrical balance in the 326 tube circuit is obtained by means of a potentiometer shunted across the filament circuit with the center tap connected to the B-minus. The filter system of the rectifier consists of a two section "brute force" choke and condenser arrangement. The condensers used in the filter are of 2 mfd. each.



A VIEW BEHIND THE PANEL

A four-section voltage divider resistance is employed to obtain the various output voltages from the rectifier. The 180 volts necessary for the power tube are obtained by tapping the mid-section of the rectifier filter. The voltage drop in the rectifier output occasioned by the drain across the voltage divider resistance reduces the output voltage to a value suitable to the application of the plate of the three r.f. amplifiers and the first a.f. amplifier. These four tubes receive like values of plate voltage. A 3000-ohm resistance is employed to reduce the rectifier output voltage to a value suitable for the detector plate voltage. A 220-ohm resistance is employed to produce a C voltage which is applied to all tubes other than the output power tube. The C-bias for this tube is obtained by means of another resistance of 910 ohms located within the power unit. Control of the r.f. and first a.f. filament is made possible by means of a rheostat rated at 0.2 ohm in series with the 1½-volt filament winding. The speaker is coupled to the output tube by means of a choke condenser system where the condenser is of 2 mfd capacity. The panel light mounted on the front panel is operated by means of the power switch and the filament potential is obtained from the five-volt winding which supplies the power tube filament. The filament leads for the power tube and the CX-326 tubes and the B and C voltage leads for all tubes other than the power tube are contained in one cable.

The photograph shows the parts lay-out of the receiver exclusive of the power system. The receiver is equipped with a single tuning control. Supplementing this control, however, is another in the form of a vernier for the r.f. input system.



THE CIRCUIT OF THE KOLSTER 6K A. C. RECEIVER

AS THE BROADCASTER SEES IT

BY CARL DREHER

Note on Programs

IT DOES a man good to theorize, once in a while, on a subject about which he really knows little. It may not benefit anyone else, but every writer is entitled to such holidays. Writing with a considerable degree of knowledge and experience is deadening to the spirit. I, for example, am an engineer in the ways of broadcasting. I am not risking much when I recite Ohm's Law for the customers or tell them they should not use 378-W microphones for paper-weights. That is not to say that I know all about such things, but I can't help knowing something, and the readers give me the benefit of whatever doubt there is, sometimes, even, with more confidence in the accuracy of my opinions than I have myself. But concerning broadcast programs I know nothing. I have never composed one; I have never even sat in the same office with any of the lyric poets who are entrusted with this duty.

Usually I do not cogitate particularly about programs. I am satisfied if they leap from the antennas with reasonable fidelity and no interruptions. What got me to thinking about them was an evening (and morning) I happened to spend at a Russian cabaret on Lenox Avenue in New York. Not being a connoisseur of cabarets, I did not find the place for myself; some friends took me there. It was a small place in a very ordinary neighborhood, with tables ranged closely along the walls, a two-by-four dance floor, and grotesque frescoes of moujiks in blouses. The patrons were mostly Russians, with an admixture of Americans, including the handsome young cops on the near-by beats, who, in civies, appeared around 2 A. M. with their girls. At one end of the room a small platform held an upright piano, competently played by a faded lady in an evening gown. She accompanied, by turns, a violinist and a baritone. The violinist played numbers which, with some exceptions, I had heard often enough on the radio. The songs offered by the baritone, however, were novelties to me—native Russian melodies which were sweet in my jaded ears, calloused by thousands of repetitions of the "Song of the Volga Boatmen"—I wish to God they could be sunk five fathoms deep in their river if there is no other way of suppressing their chantey. Later an accordion player, who records for one of the phonograph companies, performed on his instrument with an astonishing virtuosity. Sitting at a table opposite a girl, this man could make violent love simply by looking at the object of his admiration and playing the accordion, sometimes with wistful softness, sometimes with violent crashes which, in the small room, sounded like the swells of Roxy's organ. The customers joined in the choruses, and I am bound to say that everybody seemed to be having a nicer time—and at less expense—than at any of the Broadway clubs where I have left two days' salary. It was interesting to see how naturally all these different people—the Russian émigrés, the young Irish-American patrolmen, a few people from the phonograph companies, some normally hard-boiled business men, and a scattering of nondescripts, were able to have a good time together. And they were able to have it with much less drinking than in average night clubs. It was this apparent community of interest which made me think of radio program technique. Here a lot of Russians, ordinary U. S. business men, the constables and their girls, were all having a good time in an exotic milieu as far removed from the usual scenes of radio as anything I could imagine. It made me wonder whether the program managers do not underestimate the flexibility of their audiences, whether their fear that any offering which is not the radio equivalent of the *Saturday Evening Post* must fail is altogether justified.

Of course, I can see why the program concoctors feel they must play safe. Radio programs are essentially a means of cultivating public friendship, of acquiring the good will of a large number of people. The idea is to give the public what it wants and not to offend it. What the public wants is an indefinite quantity; the business of the show business is constantly to try out things and see whether the public likes them or not. You succeed and make money, or you fail and lose money. Nobody knew that the public, or a section of it, would want "What Price Glory" and pay $3.85 per individual to see it, but that turned out to be the case, luckily for Messrs. Stallings, Anderson, and Hopkins. But the break might just as easily have gone the other way. If, then, you can draw on a large body of material which is fairly certain to have general appeal and not to hurt anyone's feelings, you are doing the wise thing from the commercial standpoint. Such a body of material exists. It is based on the primal occupations of ordinary human beings. A girl with a charming voice singing "Thank God for a Garden" will offend no one but a few atheists, and it may afford a mild pleasure to a lot of listeners who like gardens, sweet voices, and tunes they have heard before. The "Four Indian Love Lyrics," the Barcarolle from the "Tales of Hoffman," "O, Promise Me" and a few thousand other things are in the same category. The broadcasters, with occasional exceptions, inevitably slide into that category. Why should they monkey with dangerous artistic creations which, while they are new, are likely to arouse passions and interfere, perhaps, with the sale of goods. Walter Damrosch told us over the radio the other night that when his father first conducted the "Ride of the Valkyrie" half the audience hooted and whistled and the piece had to be played over again. At the premiere of *The Playboy of the Western World* there was a riot. Walt Whitman lost his job because he wrote *Leaves of Grass*. So we stick to "My Blue Heaven" and "My Ohio Home." "Old Black Joe" is nice, too.

But there is always the specter of boredom in the background. Nothing venture, nothing have. As a relative outsider, I am unable to say how much should be ventured. I would suggest, however, that both extremes are dangerous. Certainly I am far from arguing that radio broadcasting should become an experimental theater for any of the arts. There is not the slightest chance of such a move being made or of its succeeding if anyone has the temerity to make it. But extreme conservatism is also dangerous, the more so because it presents a deceptive appearance of security. What does the broadcaster gain by providing a musical background for home conversation about the stock market, automobile accidents, and golf? An intermediate position would seem to be most rational for broadcasters who want to plan for the future rather than to let the future do what it likes with them. A lot of interesting novelties could be dug up by a broadcaster who wanted to scout around in places like the Russian cabaret I described. Properly staged, some of those gypsy songs might go over better than "Annie Laurie." I haven't the ideas myself; I am simply expressing the feeling that the material is there and is being neglected because the people doing the job are afraid to go off the beaten track. Or take a literary instance. Has anybody ever tried radio-dramatizing Conrad's *The Shadow Line?* It contains in the story of an ill-starred sea voyage a matchless description of the bravery of a young sailor during the hours of danger, and his collapse when safety has been reached, because he has a weak heart and is afraid he will die—he who faced death intrepidly from the outside cannot face it from the inside. If part of that novel cannot be done successfully on the radio, plenty of others in its class can be done—but as things now stand such attempts are seldom even considered. The nearest approach to it I can think of is the Eveready portrayal of a somewhat inebriated young woman acting up in a night club. The world contains enough interesting situations, stories, and music to make radio programs more alive than most of them are, but we must get rid of a good deal of our caution, our fear for our incomes, and our Pecksniffian ideas before we can utilize them. That will not be, I suspect, until we have to utilize them, but that day may be nearer than some of the brethren realize.

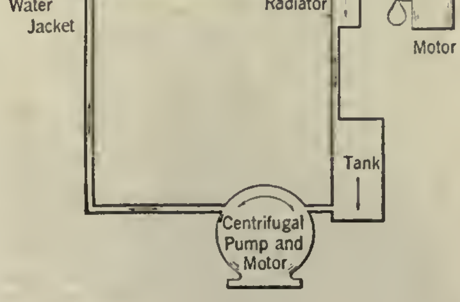


FIG. 1

Design and Operation of Broadcast Stations

21. *Water-Cooled Vacuum Tubes*

THE water-cooled vacuum tube falls into the class of energy converters in which each unit is required to handle so much power that its internal losses endanger its further existence. Lost power, in general, must be dissipated as heat. Usually by making the machine large enough we can keep the temperature rise within safe limits, but it is often more convenient to make the dimensions relatively small and to

use special means of cooling. Water and air are generally used cooling agents, sometimes without special means to secure motion, as in the ordinary small vacuum tube which radiates heat like an electric lamp, sometimes with forced air cooling, as when a fan is directed on a hot bearing, and sometimes, as in the water-cooled vacuum tube, in the form of a stream of water constantly pumped past the surface which requires cooling. The last means is the most effective and also the most elaborate and inconvenient. It has the added disadvantage that, once the apparatus is designed to rely on it, the flow of cooling liquid must be maintained whenever the power is on, or destruction of the unit will result.

Fig. 2 is a sketch of a water-cooled vacuum tube. Looked at from the outside such a tube is about half glass and half metal. The cathode or filament end is glass. At this end the filament leads are brought out, and generally the grid lead issues along the side of the glass cylinder a few inches below the filament terminals. The anode or plate is the portion of a tube which gets hottest from the electron bombardment, as may be seen in a radiation—or air-cooled—tube when the metal of the plate becomes red hot. The obvious device is then to make the anode a part of the vacuum-enclosing wall of the tube and to cool it on the outside by running water over it. The lower half of the tube shown is, accordingly, the plate itself in the form of a hollow cylinder, with the grid and filament inside. This construction entails an air-tight seal between the glass and metal, and until the development of such seals to commercial practicability, water-cooled vacuum tubes could not be built. A tube is conceivable in which the entire outer container would act as the anode and the filament and grid leads would be brought out through hermetically sealed insulating bushings, but to make such outlets air-tight and at the same time capable of standing up under thousands of volts potential between the leads and the metal of the plate-container would be an excessively difficult job. The practicable form of the water-cooled tube is that shown, in which a glass cylinder is used to support the low tension elements and to bring out conductors from them safely, and the water surrounds the metal anode only.

In the water-cooled tube all three methods of transfer of heat mentioned in physics courses—conduction, convection, and radiation—are active. Heat is radiated from the outside of the tube and water-jacket, and within the water-jacket convection takes place, as well as direct conduction from the hot metal of the anode to the water. The last mode of transfer predominates and the tube cannot survive unless it is kept up. Water is not the only possible cooling liquid for vacuum tubes. Other non-conducting or very poorly conducting liquids may be used; oil, in fact, is superior in some instances, as at very high radio frequencies.

The weakest portions of a vacuum tube are naturally the seals, and, in a water-cooled unit, especially the anode seal, because of its special construction and large size. The principle used is to make the metal at the seal very thin (a few thousandths of an inch) and soft, so that it will adhere to the hot glass in cooling, during the process of manufacture. This leaves a highly vulnerable belt at this point, where a break or puncture may readily be caused.

Usually one side of the filament in these large tubes is at ground potential, and the plate is maintained at a positive potential of several thousand volts. The tube plates must accordingly be insulated from the ground, but as the water supply system, containing tanks and mains, is normally grounded, it becomes necessary to use some special device to insulate the anodes while supplying water to them. This is accomplished by the use of such long columns of water in hose made of insulating material that the resistance is of the order of a megohm. Usually it is convenient to wind the length of hose required around a cylindrical form; such water coils, as they are called, are one of the principal outward features of large vacuum tube transmitters. The length of hose needed depends, of course, on the specific resistance of the water; fifteen feet for each tube is a common length.

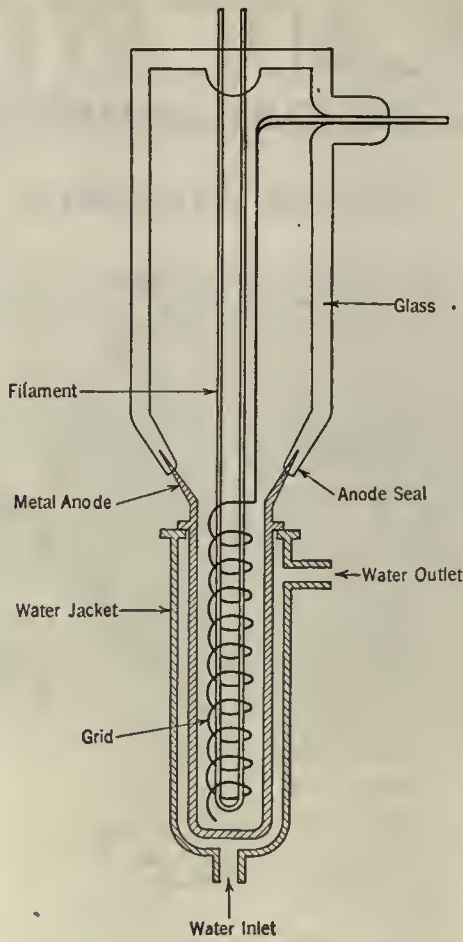


FIG. 2

Fig. 1 illustrates schematically the layout of such a cooling system, showing a vacuum tube, its water jacket surrounding the anode, the water coil, a pump for maintaining the water flow, and a radiator for cooling the water before it returns to the anode. Any of the methods of water cooling used in steam plants, such as cooling towers in which the water falls successively into vertically arranged troughs, or cooling ponds with or without sprays, are applicable to radio transmitters requiring special cooling measures. When the cooling system is closed the same water may be used over and over. Such circulatory systems are of course essential when the cooling fluid is too expensive to be wasted, as in the case of distilled water. If a plentiful supply of suitable water under sufficient pressure is available an open system is less expensive. For example, a radio station might take water from a river sufficiently far upstream to get the required head and then discharge it through a tail race like that of a hydro-electric power plant. In some instances radio stations get cooling water from city water supply systems. But water from the usual sources, even if it is clean, apparently free from suspended matter, and drinkable, may not be useful for cooling vacuum tubes. Impurities in the water may cause the formation of scale on the outside of the hot anode, as in boiler tubes. But in the case of a vacuum tube, this deposit is much more serious, because it interferes with the rapid transfer of heat from the plate to the water stream and results in gassing and destruction of the tubes. The rate of deposition of scale depends on the chemicals in the water, the temperature of the anode, and the rate of flow of the water; for a given quality of water more scale is deposited in a given time as the temperature increases. Hence, in modern water-jacket design rapid water flow is the objective; a relatively thin stream is shot past the plates. Soft or distilled water is much to be preferred to hard water for radio cooling purposes. The suitability of the water may be determined by analysis. The table below shows the chemical content held in solution in the cooling water of four different radio stations:

SUBSTANCE	GRAINS PER GALLON 1	2	3	4
Calcium carbonate	4.73	0.26	3.85	None
Calcium sulphate	None	2.76	Trace	0.45
Sodium carbonate	3.91	None	None	None
Sodium sulphate	3.09	0.28	0.24	None
Sodium chloride	1.02	1.02	0.85	0.67
Sodium and potassium nitrates	0.41	None	None	None
Magnesium carbonate	1.37	0.13	1.68	None
Magnesium sulphate	None	0.76	0.19	0.47
Aluminum and iron oxides	0.36	Trace	Trace	Trace
Silica	1.22	0.17	0.81	0.15
TOTAL	16.11	5.38	7.62	1.74

Specimen No. 1 came from the water supply of a mid-western town, and the station using it had a poor tube record as might be expected. The second and third samples were from wells, and the stations using them were only a few miles apart in the eastern part of the country. Although the total grains per gallon figures are not so far apart for the two, it will be noticed that the distribution among the substances listed is quite different. These two samples are probably average, and each deposited considerable scale under normal operating conditions. Specimen No. 4 came from a spring near by. As far as these salts go it is almost as good as distilled water. However, organic matter is also found and may play a considerable part in the deposition, as was shown in one case where scale formed rapidly during the summer and more moderately during the winter, although the difference in operating temperature was not enough to explain the effect. When all is said and done the best course, with tube prices what they are, is to use a closed circulatory system employing distilled water.

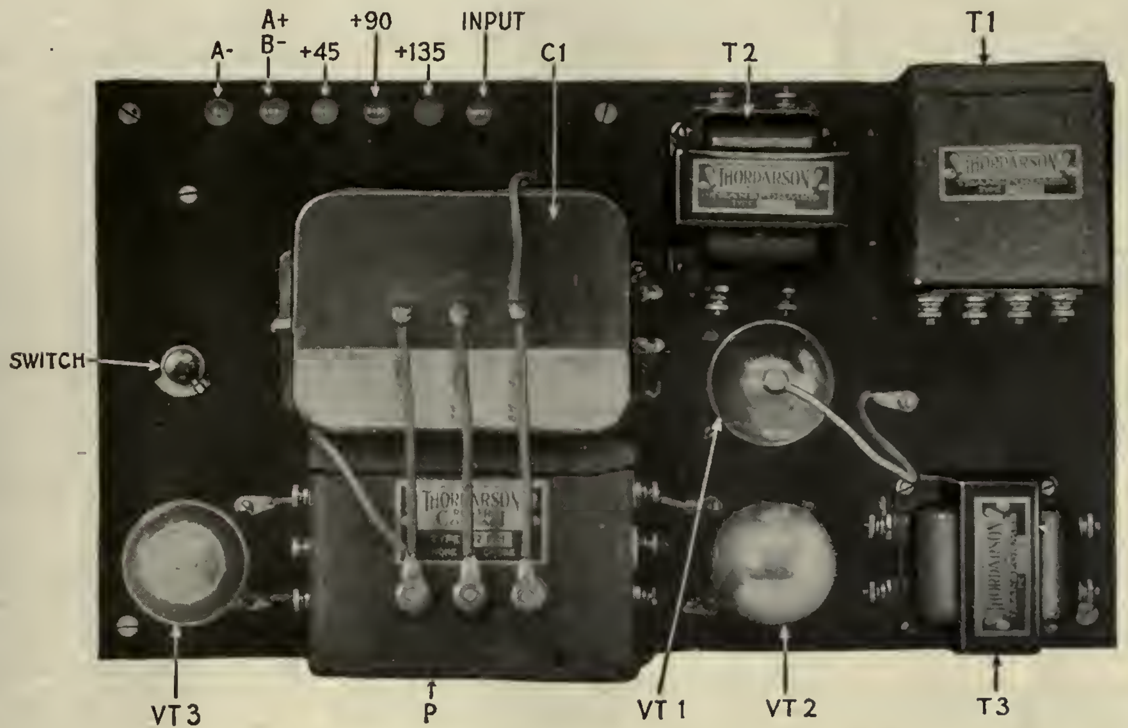
The temperature of the water is usually measured at two points on each frame before and after it has passed the anodes. Tube manufacturers generally specify an outlet temperature of 70 degrees Centigrade as the limit. As a matter of fact this is much too high for the best conditions of operation, especially by broadcast standards. A figure around 30 degrees Centigrade is more to be desired. If the flow is adequate the inlet and outlet temperatures will not differ by more than five degrees Centigrade.

When the temperature and composition of the cooling water are such that scale deposition cannot be avoided, the only remedy is to institute a regular cleaning schedule for the anodes. Dilute hydrochloric acid in a four-to-one solution may be used. Each tube must be removed from the transmitter periodically and the anode immersed in this solution, which may be held in a stone or crockery container. If the scale forms rapidly each tube must be cleaned once a week or even oftener. Such frequent removal of the tubes from the transmitter entails added danger of breakage. The acid may be run through the water jackets to obviate this, but of course it must be thoroughly washed out before power is again applied to the set.

A Space-Charge Amplifier and B Supply

By H. P. MANLY

Thordarson Electric Manufacturing Company



HOW THE INSTRUMENTS ARE MOUNTED

THE new screen-grid tube may be used in two ways, one as a screen-grid amplifier at radio frequencies, the other as a space-charge tube at audio frequencies. So far as we know this is the first description of an amplifier using this tube as a space-charge audio-frequency amplifier. A unit built in the Laboratory and operated from d.c. shows a good low-frequency characteristic, but fell off somewhat above 2000 cycles due to the high input capacity of the screen-grid tube. The ratio of voltage (across 4000 ohms) in the output to the input 0.1 volt at 1000 cycles, was 240, which indicates a voltage step-up in the system from input to the grid of the power tube of 120, compared to 72 which is the step-up in the average two-stage transformer-coupled amplifier.

The Thordarson amplifier power-supply illustrated here when tested in the Laboratory had a tendency to motorboat which was corrected by connecting a 25,000-ohm resistance in the 45-volt lead and by passing it to ground as shown in the circuit diagram. Owing to the fact that the entire unit is built in a rather small space, the output is not too free of hum, and the experimenter is advised to arrange his apparatus with a little more room between parts.

—THE EDITOR.

THE popular quest for greater volume generally leads to a multiplicity of tubes which add to the cost and complication of the receiver while opening the way to various troubles difficult to overcome. An amplifier which adds the effect of more tubes, without the tubes, forms an interesting and worth-while solution of the problem.

This unit is of the two-stage type and in its first stage uses one of the new screen-grid tubes as a space-charge amplifier connected to the power tube through a Z-coupler, a device which consists of two high-impedance windings built on two separate cores and placed within one case.

As employed in this amplifier, the inner grid of the tube takes no part in handling the signal but is used solely to reduce the effect of the space charge around the filament. This space charge, which in other tubes strongly opposes the flow of electrons between filament and plate, is a negative charge. By maintaining the inner grid, near the filament, at a rather strong positive voltage, the troublesome space charge is reduced and the amplification is greatly increased.

The outer grid, which almost completely surrounds the plate, is used as a control grid and receives the voltage changes which represent the signal to be amplified. Such use of the two grids is the reverse of the practice followed when the tube is used as a screen-grid amplifier.

With a strong voltage from the detector stage almost any audio amplifier will deliver all the voltage a power tube will handle with only moderate amplification in the first audio stage. But with a weak signal and correspondingly weak voltages from the detector, this moderate amplification will not be sufficient to produce good loud speaker volume. It is under such conditions the space-charge amplifier stage affords real improvement because it steps up the weak voltage and delivers a comparatively strong impulse to the power tube's grid.

FACTORS DETERMINING VOLUME IN OUTPUT

AS IS well known, the effective or overall amplification of any tube and its coupling device depends not only on the amplification factor of the tube but also on the amount of impedance in the external circuit of the tube. Using the 222 type tube as a space-charge amplifier it is found to have a plate impedance of about 125,000 ohms and an amplification factor of approximately one hundred. The greater the external impedance, the greater will be the proportion of this theoretical amplification actually realized and impressed as grid voltage on the power tube.

The required high impedance for the external plate circuit is secured from one winding of the Z-coupler, connected between the plate of the space-charge tube and the plate current supply for that tube. The other winding is placed between the grid of the power tube and the filament circuit of that tube. The a.c. voltage variations across the plate circuit winding are passed on to the grid of the power tube through a coupling condenser, C_3, in Fig. 1.

With an impedance type of coupling using a resistance grid-leak there is a decided tendency for the power tube's grid to block on strong signals. The second coupler winding, connected between the power tube grid and the filament circuit, provides an escape for the excessive collection of electrons which produce the blocking. It has a relatively high impedance and comparatively low d.c. resistance.

Heretofore, the screen-grid tube has been used chiefly in radio-frequency amplifiers, and then with the screen-grid method of connection. The screen-grid connection is especially favorable for such use because it reduces the tube's grid-plate capacity and lessens the consequent internal feedback. In audio-frequency amplification, this capacity is of comparatively little importance and using the tube as a space-charge device secures advantages which are especially desired for this kind of work. As a space-charge amplifier, the tube is free from a tendency to howl which,

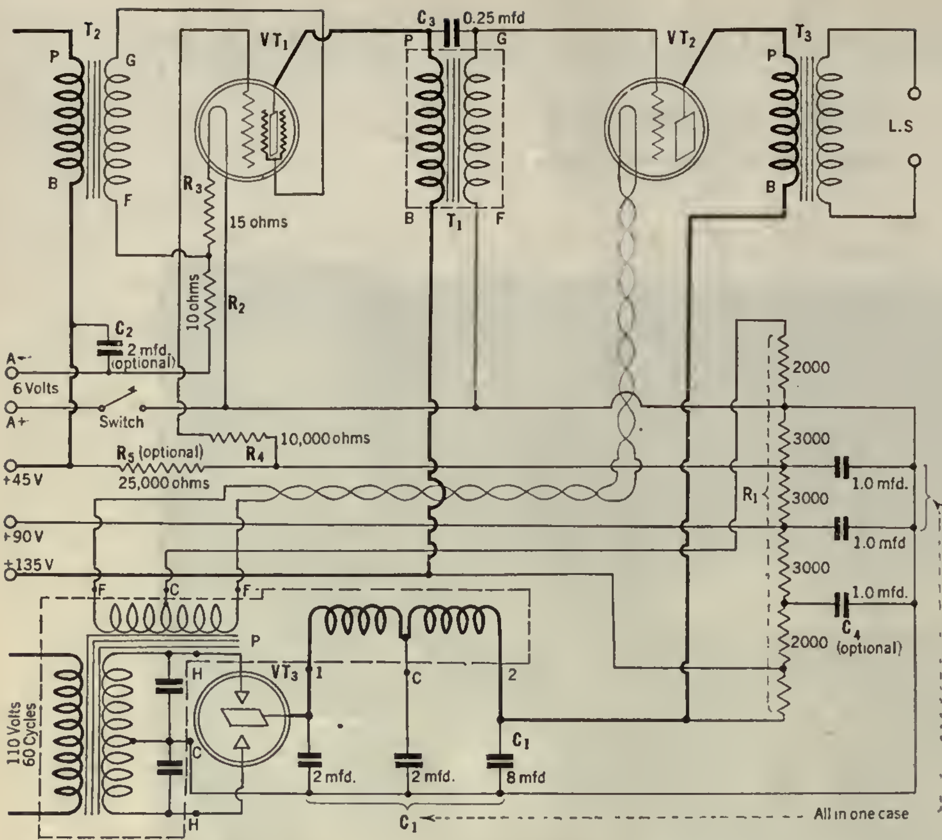


FIG. 1

The resistance, R_5, and the 2.0-mfd. condenser on the receiver side of it, C_2, is a trap into which motor-boating tendencies fall. It is applicable to resistance-and impedance-coupled audio amplifiers and was first described in April RADIO BROADCAST. The one-mfd. condenser, C_4, from the 135-volt tap to ground may not be necessary. The Thordarson engineers state that a 0.02 mfd. condenser at C_3 will cause the circuit to amplify still more at 90 cycles without decreasing the high frequencies

using a screen-grid connection, is sometimes produced by a microphonic feedback from the loud speaker.

USES OF THIS AMPLIFIER

THIS amplifier has been developed primarily as a replacement unit for use with a radio-frequency system which, with its original audio amplifier, does not produce sufficient output to deliver good loud speaker volume on weak incoming signals.

The complete device includes a two-stage audio-frequency amplifier and also a B power-supply unit capable of handling not only the audio-frequency requirements but several radio-frequency tubes and a detector as well. It will take the place of the audio-frequency system in any existing receiver when connected to the output or plate terminal of the detector. The space-charge tube takes only one eighth ampere of filament current, which may be furnished by an A-battery of either the storage or dry cell type.

The audio-frequency amplifier uses transformer coupling between the detector tube and the space-charge tube. The Z-coupler is used between the space-charge tube and the power tube. Direct current is kept out of the speaker by a coupling transformer which follows the power tube.

The power unit for this amplifier includes a "compact," P, having a transformer, two filter chokes and two buffer condensers for the rectifier tube, all within one case. In addition to the high voltage winding on the transformer there is also a center-tapped filament winding for the power tube. The condenser block contains filter condensers and also the two 90- and 45-volt tap bypass condensers, C_2 and C_3. An additional 1.0-mfd. condenser may be necessary across the 135 volt top as indicated on Fig. 1 and if the 25,000 ohm anti-motorboat resistor is used, it needs a 2.0-mfd. condenser. These are not shown on the photographs.

All plate voltages are secured from a single voltage-dividing resistance unit, R_1, having taps at the proper places. Grid bias for the space-charge tube is secured by the drop across the filament resistor, R_2. Grid bias for the power tube is secured from a part of the voltage-dividing resistance, R_1. The inner, or space-charge grid, is supplied with a positive charge of approximately twenty-two volts through the 10,000-ohm resistor, R_4, connected to the forty-five volt line.

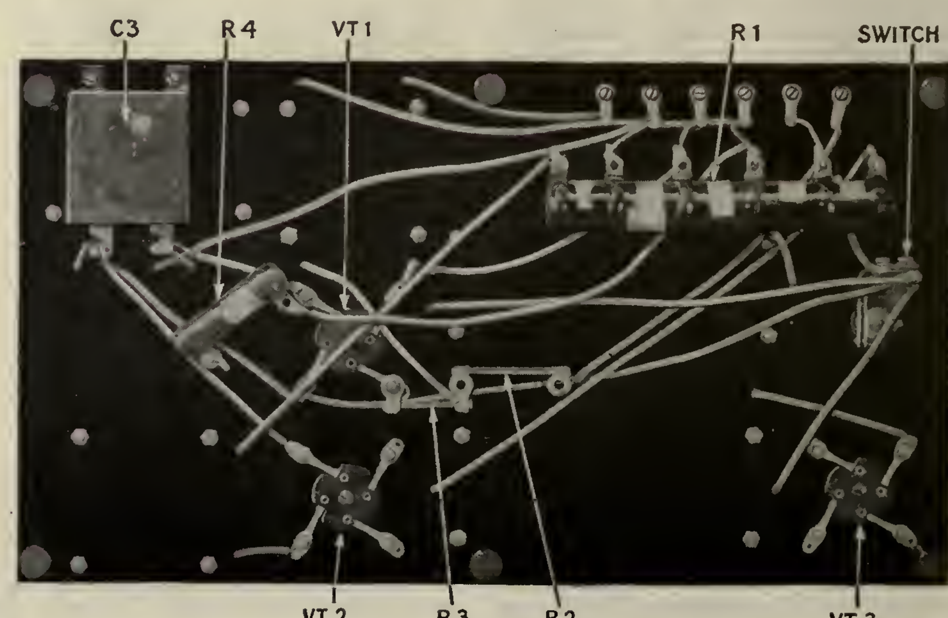
There are six binding posts. One is for a connection to the detector tube plate, two are for A-battery connections and the remaining three provide connections at 135 volts, 90 volts and 45 volts for a radio-frequency amplifier of any type.

In utilizing this amplifier with a previously built radio-frequency system no additional controls are required. Volume is controlled from the radio frequency end of the combination.

PARTS LIST

T_1	1	Thordarson Z-Coupler, T-2909
T_2	1	Thordarson A. F. transformer, R-300
T_3	1	Thordarson speaker coupling transformer, R-76
P	1	Thordarson power compact, R-171
R_1	1	Thordarson-Ward Leonard resistance unit R-508-1
C_1	1	Dubilier B-block, R-171
C_2	1	Dubilier fixed condenser 2 mfd. (optional)
C_3	1	Dubiler fixed condenser, ¼ mfd.
C_4	1	Dubilier fixed condenser, 1 mfd. (optional)
R_2	1	Yaxley 10-ohm filament resistor
R_3	1	Yaxley 15-ohm filament resistor
R_4	1	Ward Leonard 10,000-ohm resistor
R_5	2	Ward Leonard Resistance 25,000-ohms (optional)
	3	Benjamin cushion sockets, 9044
Sw	1	Yaxley switch s. p. s. t.
	6	X-L bakelite top push posts (Input, A + B—, A—, B + 135, B + 90, B + 45)
VT_2	1	Power tube, UX-171A or CX-371A
VT_1	1	Screen grid tube, UX-222 or CX-322
VT_3	1	Raytheon BH rectifier tube

[The only special part in the above list is the Thordarson Z-coupler. Naturally, any dependable input and output transformer or condensers may be used, provided they are electrically similar to what the author specifies. The resistors must have the correct resistance and be able to dissipate the proper amount of heat. Readers may obtain the manufacturer's literature in this amplifier from RADIO BROADCAST or from the manufacturer direct—*Editor.*]



THE INSTRUMENTS AND WIRING UNDER THE SUBPANEL

The Listener's Point of View

A FINE PROGRAM YOU WILL NEVER HEAR

By JOHN WALLACE

WE HAVE recently received an announcement—now old news, but still good news—which we consider the most significant manifesto so far issued in the history of radio in America. Significant and important in spite of the fact that probably not more than one out of a dozen readers of these lines will ever hear one of the programs promised in the announcement.

The long heralded course of music education programs by Walter Damrosch is now assured and will definitely commence next fall. A series of twenty-four educational orchestral concerts will be broadcast beginning October 26. The Radio Corporation of America is sponsoring the series, which will be given Friday mornings at 11 o'clock Eastern Standard Time. It is planned to use twenty-eight stations, the Blue Network and associated stations, covering the entire country between the Atlantic Ocean and the Rocky Mountains. The concerts will be received in the class rooms of both grammar and high schools and the hopes are to reach an audience of from twelve to fifteen million children.

We claim that the announcement is an important one in spite of the fact that it doesn't mean a whoop, personally, to either you or ourself. We shall both, doubtless, be far removed from radio loud speakers at 11 o'clock of Friday mornings. Its significance lies in the fact that it is really the first move toward making radio a definitely educational factor in this country. There have been sporadic attempts at educating by radio before, but none on more than a local scale, and none of any very efficient organization.

We do not intend to slight the fact that radio has already proven its worth as an informational medium. Under this heading comes its vast service to farmers in giving them market and weather reports and other valuable information. But the RCA Music Education Hour is in our opinion the first radio service which can honestly be labeled *educational*. In a history of radio written fifty years hence, its inception will constitute one of the first important early chapters.

Its purpose, according to Mr. Damrosch, will be

"primarily to arouse enthusiasm and a better understanding of music as an artistic expression of human emotions. Secondly, to encourage self-expression in music among the pupils and, therefore, the study of music in the regular curriculum of the schools. This should develop, first of all, singing, a knowledge of musical notation, and in the high schools and colleges, the formation of school orchestras. My experience of over thirty years in this field has proven to me that all these things come inevitably and naturally.

"At all of these concerts I shall give very short and simple explanations of the music that the orchestra will play, of the nature and character of the different orchestral instruments, and something about the composers.

"It is my purpose to prepare this summer the entire twenty-four programs, and at the same time to formulate a list of about twelve questions for each program which will embody the principal points of my explanatory comments, and which will be sent to all the schools connected with us by radio, so that the teachers may use these questions, all or in part, some time after each concert. We will also send the proper answers to these questions for the use of the teachers only, and follow these answers by additional information which the teachers can impart to their pupils at their discretion."

A New Plan for School Broadcasts

THERE have been various attempts at broadcasting courses other than music appreciation. There is hardly a single branch of learning that hasn't been essayed at some time or other. These attempts, as we have made known in these columns before, have filled us with large snorts of derisive laughter. We cannot be convinced that any of them have been of any great value. We doubt if radio home study courses will ever prove much; they offer no points of superiority over extension courses such as are now offered through other agencies, or home-study from books.

But the use of radio as an adjunct to the organized work of the class room has always seemed to us feasible. With the Damrosch lectures as an opening wedge there is no reason why other courses should not follow. To this end there is already in existence a committee which styles itself the Preliminary Committee on Educational Broadcasting, which is, in its own words "an informal committee working together because of our interest. We believe that there is a wealth of material, that schools can satisfactorily receive the programs, and that if educators show sufficient interest the broadcasting will be financed. In other words, that radio may give every teacher valuable assistance in the class room."

A WGR ARTIST

Edna Zahm, soprano, is a regular artist on the staff of station WGR, at Buffalo

This committee has attacked the problem in an expert fashion and has carried it to the point where it is a definite plan to accept or reject. However, its acceptance or rejection is entirely in the hands of the educators. The radio structure is ready to be employed provided the more difficult educational problems are solved. This preliminary committee has very well anticipated most of the problems—probably by consulting the British Broadcasting Corporation, which has had several years' experience in such broadcasting—and has answered in advance most of the possible objections. A few of the objections are answered thuswise:

1. Curriculum already too full!

Not a single branch will be added. The Plan merely substitutes occasional expert instruction in certain studies and presentations by great national leaders, the living leaders whom succeeding generations will study about in text books.

2. Instructions cannot be given satisfactorily over the radio, because:—

(a) the loud speaker lacks the personality of a teacher—the flash of the eye, the smile, the frown, the gesture. It cannot hold the attention of the pupil.

It can hold the attention. Experience proves that it can, not only during the novelty period, but whenever the broadcasting is properly done. The teacher does not leave the room. She is on hand—her personality is as effective as ever and her time is free to follow the lesson with pointer to map, with notes on the blackboard, with supervision in the doing of things in which the radio instructor may be guiding the class.

It is not a substitution—it is adding an assistant to the teacher staff—there is no excuse for a flagging of interest, but every reason for two teachers accomplishing more than one.

3. It lacks the socializing value of the regular teacher's conduct of a lesson.

Again a misimpression. The teacher is present, and has more time to check up on the fine points of the lesson because the Visiting Teacher of the Air is doing the heavy work. Moreover, the feeling of the student that others all over the nation are listening with him, gives him a lift in spirit and a challenge that makes him more receptive, more ambitious. Special regional, state, and national contests might be offered to stir definite rivalry.

4. It is a fad and will pass away.

The automobile was a fad, the telephone was a plaything, etc., etc.,—yet they have taken their places and are unchallenged. The radio will take its place in education and

(1) *provide an assistant teacher to every teacher who tunes-in;*

(2) *give inspiration through acquaintance with great leaders in world progress;*

(3) *provide features the smaller schools could not possibly enjoy otherwise—music instruction—appreciation, etc.;*

(4) *offer a Normal School course by master teachers at the microphone;*

BILL RAY, OF KFWB, HOLLYWOOD
Mr. Ray is standing under a new type of microphone in use at the Hollywood station

(5) *Weld home and school, because both will listen to the broadcasts;*

(6) *Brighten the life of both pupil and teacher —add zest, inspire and energize the whole day's schedule.*

It is our guess that conservatism, the basis of the last mentioned objection, will prove the most difficult stumbling block in arousing widespread demand for the innovation. Various and sundry are the complaints leveled against education to-day. Most of them are based on the assumption that there should be progress in education. Education cannot progress; it will produce no greater minds in the twentieth century than it did, say, in the fifteenth. But it can adapt itself to the changing conditions in the world. Civilization, according to the German philosopher Spengler, is the enemy of culture. Since the best way to handle any enemy is to turn his own weapons against him, it follows that radio, a product of civilization, should be utilized as an instrument of culture. A conservatism that ignores this fact is a stupid one.

RADIO'S EDUCATIONAL LIMITATIONS

THERE is no subject in the world on which it is easier to spill a lot of words than education—unless it be religion or prohibition. Present anyone with one of these three topics and he or she immediately feels qualified to spout forth lengthy and expert opinions on the subject. We shall attempt to steer clear of this pitfall by refraining from telling the Preliminary Committee on Educational Broadcasting how to run their business. They are educators by profession and should know how to handle the pedagogical end of the affair, and judging from the very complete outline of their plans which we have at hand they have done this part of the preliminary work well. However, we do concede ourself some slight knowledge of what radio can and cannot do, and since we suspect that this knowledge is not shared to any great degree by the educators we will stick in our oar.

The schedule they tentatively suggest for the "National School of the Air" is as follows:

GRADE SCHOOLS—Monday, Wednesday and Friday *HALF HOUR PERIODS*

Music Appreciation (Instructor and musicians to illustrate)
English and Literature
Dramatics—Plays, Dialogues, etc.
Geography (Travelogues)
History Dramalogues
Health Talks
Holiday Talks
Miscellaneous

HIGH SCHOOLS—Tuesday and Thursday

Music Appreciation
Dramatics—Shakespeare and others
Talks by Great Men and Women—20-minute talks and 10-minute interview

President of U. S.	Musicians
Vice-President	Physicians
Speaker of House	Naturalists
Cabinet	Inventors
Chief Justice	Explorers
Governor of State	Painters
Diplomatic Service	Sculptors
Senator	Botanists
Representative	Chemists
Authors	Physicists
Educators	Business Men
Statesmen	

SUPPLEMENTAL LIST OF SCHOOL RADIO MATERIAL

Opening Exercises
Public Speaking and Parliamentary Practice
Nature Study
Programs for Parent Teacher Associations
Current Events and Civil Government
Spelling
Art Appreciation
Boys' and Girls' Clubs
Games for School and Playground
Foreign Languages

In general we consider this a very intelligently worked out schedule. Our principal quarrel is with the relative importance attached to the various items by the teachers to whom it was submitted. The first five hundred replies to a questionnaire sent to school authorities expressed the opinion that music appreciation courses should receive the greatest stress. With this we are in entire agreement. But the teachers disclosed their ignorance of radio by placing second on the list a subject which should have received a negligible vote and by their apparent indifference to the very subjects which radio is best fitted to put across. Geography lessons were, by an overwhelming margin, placed second! This is obviously silly. Geography hasn't got anything to do with sound; it is entirely a matter of sight. Radio, a sound medium, can't do much to elucidate or enliven geography. The motion picture, evidently, is the contraption to haul in to aid this study.

Literature and English, Health and Hygiene were rated way ahead of History, Current Events, Civics and Citizenship. Another absurdity. One of the best things developed by radio impresarios is the "Great Moments in History" type of program.

And if the sense of personal contact formed by having the President of the United States speak directly to the school children is not of more importance than having some M.D. lecture them on how to wash their teeth our judgment is cock-eyed. The first question to be asked before inflicting a radio course on the children is "Can it be done better orally than in print?" Evidently the school child can learn how to wash his teeth quite as well from a pamphlet, and there be aided by illustrations too. But a forty-page booklet containing a message from the President could never approach in vividness, or stimulating appeal, the actual hearing of his voice in the class room.

The list of preferences teems with further incongruities. Nature Study and science is given a large number of votes. Foreign Languages are given none at all. Outside of a lecture by some gifted individual who could imitate bird calls we can think of no other Nature Study broadcast that could be an improvement on the same thing as taught in a book. But suppose a French class were to be treated to a lecture in the French language by some famous French personality. That would make them open up their ears and attend.

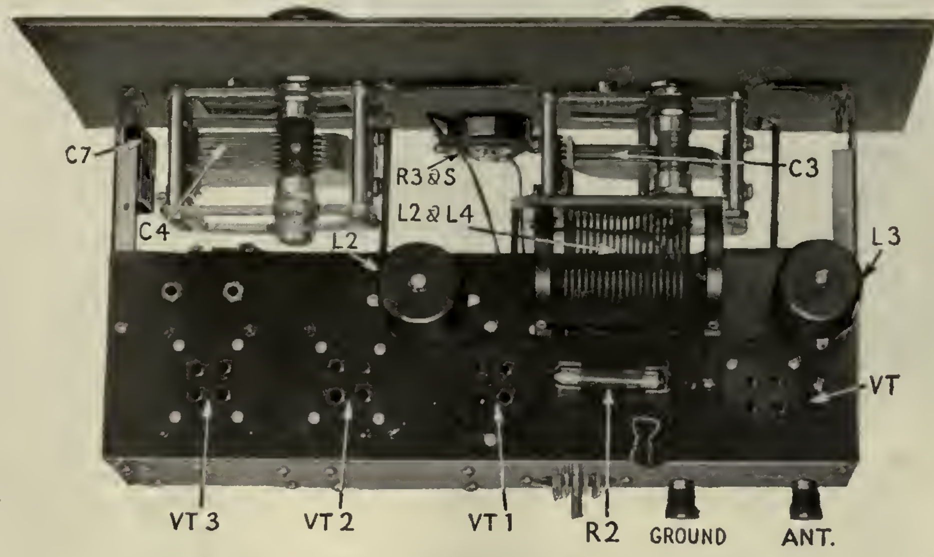
Before committing themselves to any schedule of courses the educators should be expected to put themselves through a laboratory course in what radio can and cannot do. It will take them at least two or three weeks of conscientious listening to many types of programs before they will be qualified to state with any authority just what sort of programs should be stressed.

To any who would shun the ordeal of such a laboratory experiment we offer the suggestion that the conclusion to which they will come is that *sound* must be a common factor to tie up any study with radio. From the point of view of *sound* music of course comes first. The *sound* of the voices of great leaders would be of infinite value in helping to bridge the gulf that necessarily exists between the ordinary person and the outstanding personality in this over-size nation of ours. The *sound* of foreign languages can be put to good use. The *sound* of great literature, particularly the sound of poetry, is quite as important as its appearance in print. The *sound* of a great historical event, reproduced in faithful accordance with the way it probably transpired can give the school child a vivid mind picture of the event. If any subject, considered according to this standard seems to gain nothing in vividness and aliveness by being intrusted to the loud speaker there is no excuse for adding it to the curriculum of any "University of the Air." Radio eduction must be made an improvement before it will become worth being realized in actuality.

THE PROGRAM SUPERVISOR OF WBAL, BALTIMORE
Gustav Klemm has distinguished himself through his compositions, many of which are on the repertoire of concert artists. In addition to his duties of arranging WBAL programs, Mr. Klemm also finds time to plan and direct many WBAL feature programs

A Receiver for Short-Wave Broadcast Reception

By BERT E. SMITH



A COMPACT RECEIVER FOR SHORT-WAVE WORK

THIS short-wave receiver uses a screen-grid tube preceding a conventional oscillating detector and a two-stage, transformer-coupled audio amplifier. In the Laboratory it was possible to hear code stations which were inaudible without the screen-grid tube. This means that this tube not only acted as a blocking tube to prevent the detector oscillations from getting into the ether, but contributed some amplification as well.

The receiver can be operated from a conventional plate supply device provided it is well filtered. On the very short waves—20 meters and below—any electrical noise, which may be a.c. hum, or the spark-plug system of passing trucks disturbs the receiver. A 45-volt B-battery for the detector plate circuit will give much quieter operation and enable the listener to get down to the bottom of the signal level. At the present time it is not feasible to use a.c. tubes on a short-wave receiver.

—The Editor.

IN THE design of a short-wave receiver for broadcast reception, several factors must be considered in order to produce a satisfactory product.

1. *The receiver must be essentially non-radiating.* Due to the surprising distances which may be covered by short-wave transmitters with a limited amount of power, it is essential that little or none of the high-frequency oscillations generated locally by the receiver shall reach the antenna, for otherwise, the ether would be filled with an annoying congestion of squeals and howls.

2. *Adaptability to phone or c. w. operation.* This requirement applies principally to the type of audio amplification employed in the receiver. It has been customary in receivers for c. w. operation to employ transformers having little amplification of the bass notes because c. w. signals are usually heterodyned to a high-pitched whistle and very low grade transformers are adequate for the amplification of the signals, although they amplify but little the low frequencies now transmitted by good broadcasting stations.

3. *Smooth oscillation control without extraneous noises.* This requirement will be discussed more fully and is very important, due to the fact that many "noise producing" features of a design which are completely negligible in the broadcast band, assume astounding proportions in the vicinity of twenty to thirty meters.

4. *Ease of operation.* It is quite important that a short-wave receiver should be as easily controlled as the average broadcast receiver so that the operator may not be forced to learn new procedure and new methods.

5. *Adequate range of wavelengths.* Short-wave broadcasting stations have not yet assumed a permanent status because they all have experimental licenses, and it is important that the receiver should be adapted to cover a rather wide band of frequencies.

USE OF THE SCREEN-GRID TUBE

IN ORDER to limit the radiation of the receiver, the screen-grid is at once considered as a new contribution to the short-wave receiver.

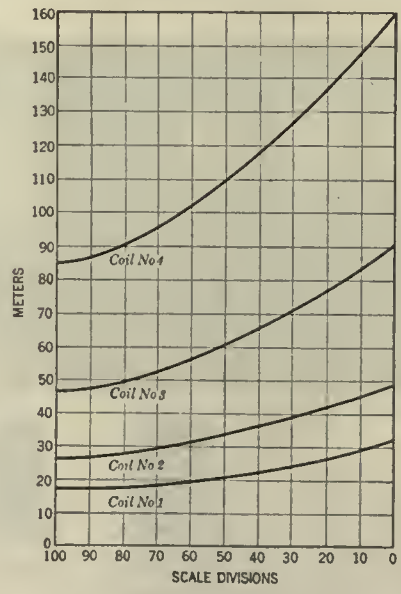
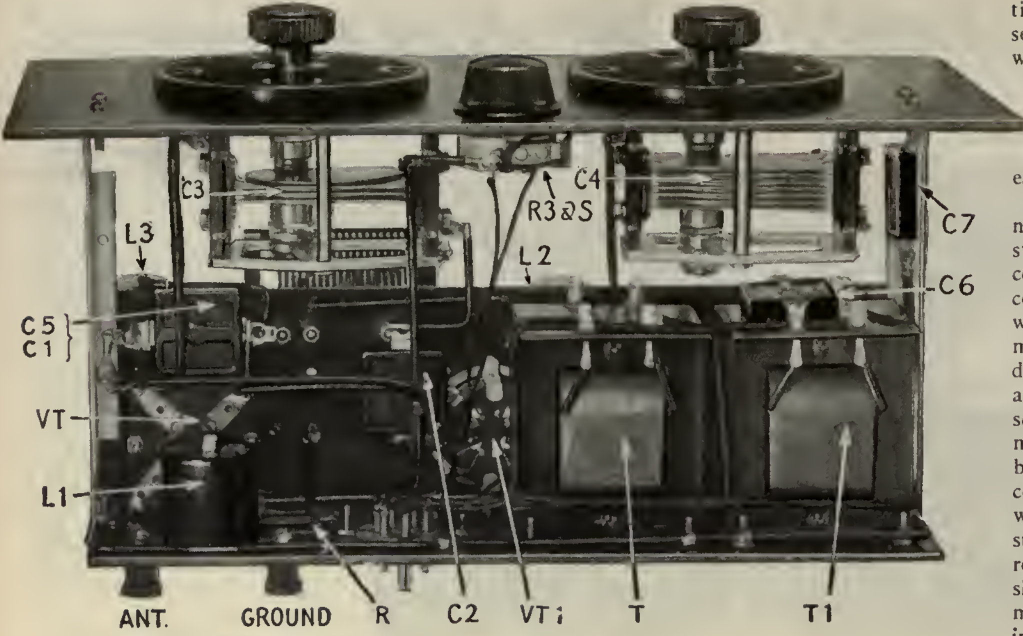


FIG. 1

The insertion of this tube between the antenna circuit and the oscillating tuned circuit of the short-wave receiver will limit the transfer of energy from the tuned circuit to the antenna, due to the extremely low grid-to-plate capacity of the 222 type of tube.

It was the original intention as the plan of this receiver was made to use the screen-grid tube as a radio-frequency amplifier with a tuned-grid circuit coupled to the antenna, but the idea was abandoned for two reasons; the first being that the tube is not strictly a non-oscillating one, and when connected with tuned circuits in the grid and plate, they must be adequately and carefully shielded; also, plug-in coils must be used in order to cover the necessary band of wavelengths, and to have shielded these circuits would have made necessary the removal of two shield tops and the replacement of two coils for each change of wave band. In addition, there is the fact that the tube possesses not zero, but an appreciable grid-to-plate capacity, which causes a disagreeable "hang-over" effect in regeneration resulting in lack of control when there are two controls to handle. It was found experimentally that a low distributed capacity r.f. choke coil served very well as an aperiodic input circuit to the screen-grid tube. This choke is shown at L_1 in the diagram, Fig. 2. It was also found that by the use of this connection a considerable degree of amplification was produced by the screen-grid tube as against coupling the antenna directly to the coil, L_2, as would be done in the conventional radiating type of receiver. This amplification was "velvet," since all we had hoped from the screen-grid tube was a blocking action, keeping detector oscillations from reaching the antenna circuit.

As connected in Fig. 2, the screen-grid tube also contributes to the ease of operation by the elimination of the so-called "holes" in the tuning range of the conventional short-wave receiver. These "holes" are due to the fact that when the set is tuned to the natural wavelength or submultiples of the natural wavelength of the antenna, sufficient energy is subtracted from the tuned circuit to cause the detector tube to cease oscillating, whereupon the antenna coupling must be reduced and again increased as the "hole"



THE UNDER SIDE

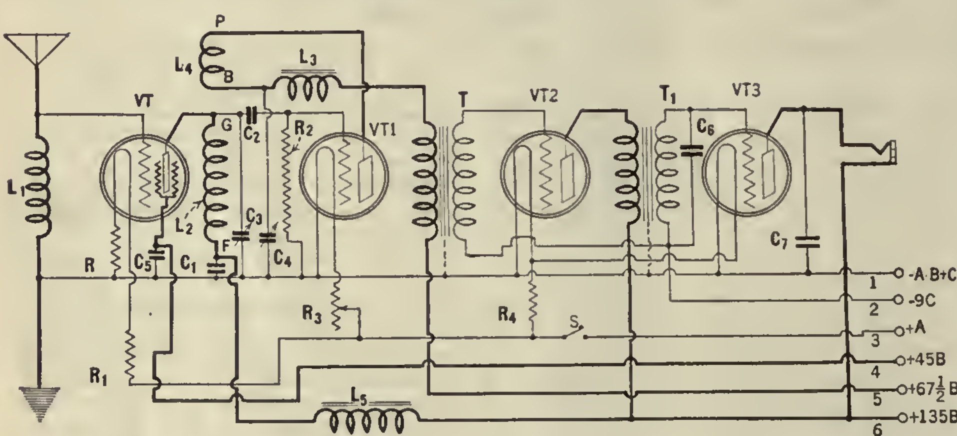


FIG. 2

is passed on the tuning dial. As was stated, the screen-grid tube, due to its low grid to plate capacity, eliminates this objectional feature and permits a band of waves to be swept by the tuning condenser, C_3, without other adjustments except a minor manipulation of the regeneration condenser, C_4.

The receiver has also been adapted to the receiving of broadcast programs by the employment of high-grade audio transformers together with a CX-312 power tube in the output circuit.

Smooth control in operation has been attained by no small amount of effort. A portion of the success of this feature is due to the splendid characteristic of the choke, L_3, which isolates the regeneration circuit, L_4, C_4, at all frequencies to which the tuner is capable of responding. Stability of control is also obtained by isolating the various circuits as completely as possible. Thus the 0.005-mfd. condenser, C_5, assures that the screen-grid will be maintained at ground r.f. potential. In the same way the plate circuit of the screen-grid tube is isolated by means of the 0.005-mfd. condenser, C_1. Because several portions of the receiver are operating from the 135-volt tap of the battery, another choke, L_5, is inserted. In order to prevent small radio-frequency currents from being carried through the stray wiring capacities of the audio amplifier, which would cause objectionable hand capacity and prevent the detector going into and out of oscillation quietly when wearing the head phones, the cores of the audio transformers are connected to the panel brackets and thence to ground; in addition the capacity, C_6, is employed across the secondary of the second audio transformer, T_1, as well as another capacity, C_7, across the output terminals of the receiver.

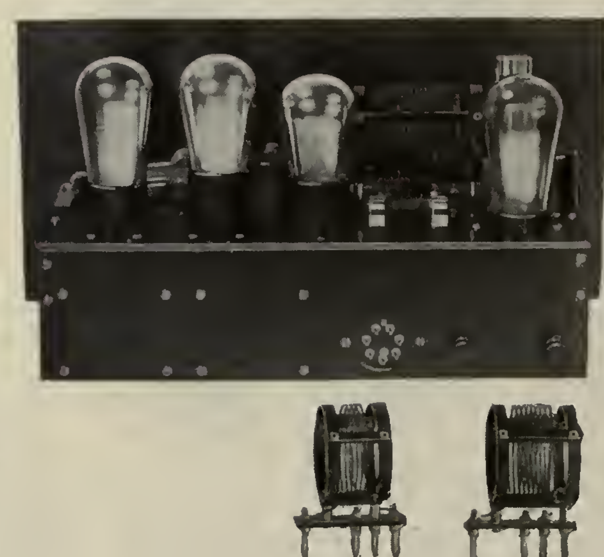
It is a fact that these improvements for eliminating audio noises in the output of the receiver contribute materially to the ease of operation of this set.

A further source of troublesome extraneous noises has been negligized by the unique construction of the Amsco 0.000014-mfd. (140 mmfd.) condenser, C_3. With a condenser of ordinary construction, unbearable noises are produced when the receiver is tuned at twenty to thirty meters due to the contact voltages set up by the dissimilar metals usually employed in the shaft and bushings of the condenser as well as to the scraping between the metal parts. Strange as it may seem at the first blush, these noises cannot be eliminated by "pigtailing" the shaft of the condenser, because at these extremely short wavelengths the inductance of the "pigtail" is sufficiently appreciable to prevent the variable resistance caused by the scraping contact to be short-circuited by it. This difficulty has been met very well by completely insulating the bearings of the rotor from the frame of the condenser and then running the "pigtail" directly from the shaft to the frame. In this way the variable resistance caused by the shaft-bearing contact is eliminated entirely and the whole circuit is carried by the "pigtail."

The wavelength range of the receiver with the four plug-in coils is from seventeen to one hundred and fifty-five meters, arranged to include all short-wave stations experimentally broadcasting at present or contemplated, as well as the principal amateur phone and telegraphic bands.

It should be noted that the construction of the Aero plug-in short-wave coils has been altered from a 3-inch diameter to a 2-inch. This change has improved the structure and rigidity of the coil; it limits the magnetic field of the coil materially by increasing the ratio of length to diameter for a given inductance; it minimizes the pickup from powerful near-by stations, and also provides a more favorable coefficient of coupling between the tickler and secondary for operation at extremely low waves.

The constructional work on this receiver has been reduced to a minimum. A foundation unit is available with drilled and engraved front panel, subpanel provided with sockets, and back panel, all of Westinghouse Micarta.



THE COMPLETED RECEIVER

NOTES ON ASSEMBLY

THE top view of the unit on page 167 shows the arrangement of this subpanel. It will be noted that the socket for the CX-322 tube, at the right, is depressed and held with machine screws and short bakelite studs, in order that this taller tube shall not project above the top of the front panel. The plug-in jacks usually contained in the Aero coil mounting have been dismounted and are supplied mounted directly in the subpanel. To the left and right of the coil mounting are the radio-frequency chokes, L_5 and L_3, respectively, and the grid leak mounting directly behind the coil.

It is wise in assembling the receiver to do as much of the work as possible on this subpanel before assembling it into the mounting proper. It will be necessary to solder long leads to the plate and grid terminals of the audio and detector sockets in order to facilitate their connection to the audio transformers after assembly.

The back panel, seen in the illustrations, should also be assembled separately with the antenna and ground binding posts, the antenna input choke, L_1, the Yaxley cable plug connector and the audio transformers, and as much work accomplished on the separate units as possible before the final assembly.

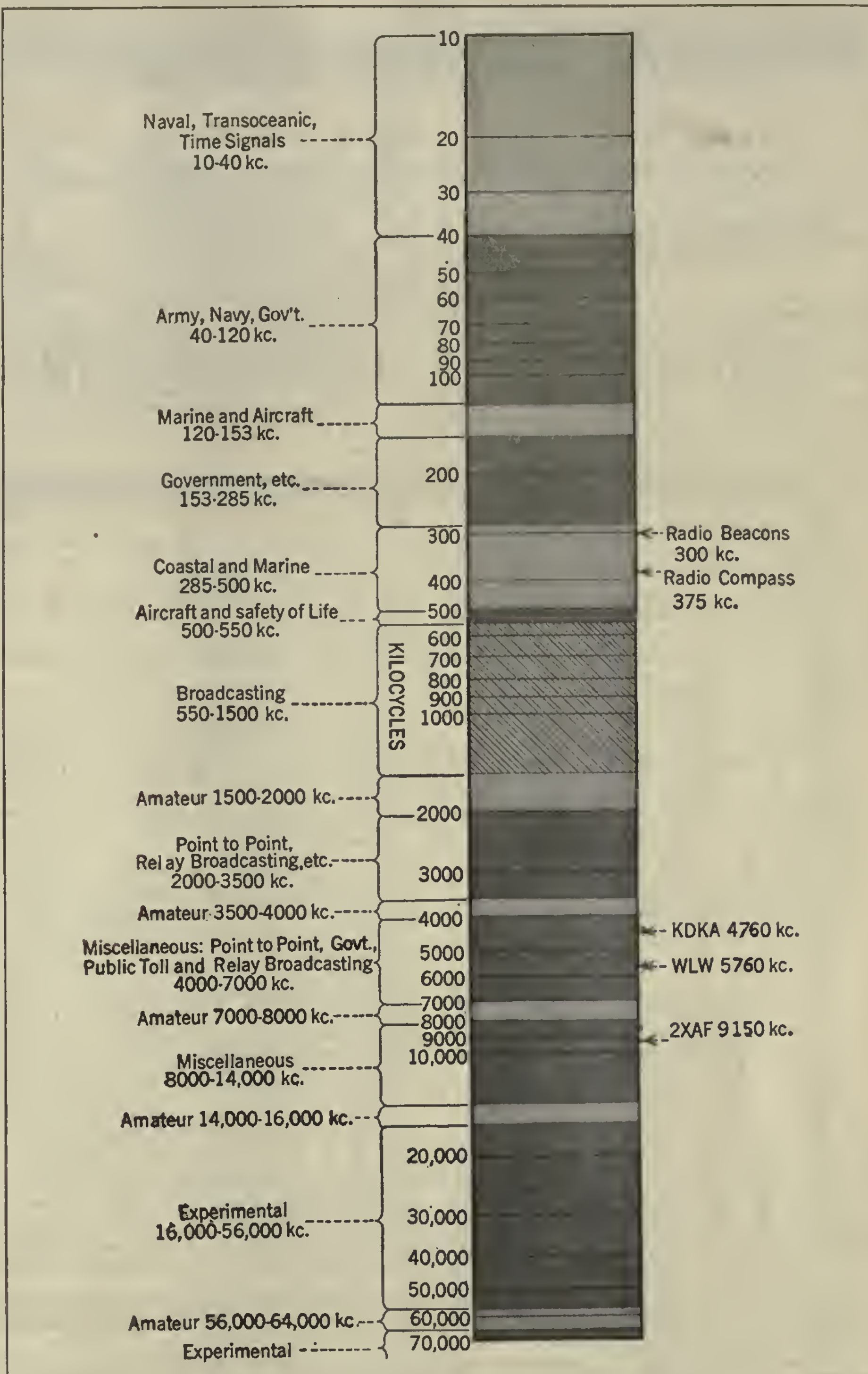
It will also be noted that the battery leads from the Yaxley connector to the audio transformers are cabled in soft wire and laced together with ordinary string. A careful application of shellac to this cable will stiffen it and make a neat appearance.

The other assembly details are made sufficiently clear, we believe, in the photographs and the wiring diagram, Fig. 2.

OPERATION

THE operation of the receiver is very simple. With suitable tubes inserted in the sockets and with the battery voltages in the circuit diagram applied, one of the coils may be placed in the socket. With the regeneration condenser, marked "Volume," all the way out, the filament rheostat is turned up to about half brilliancy. Then, advancing the "Volume" condenser to a certain point, the detector tube should go into oscillation with a soft "thud," accompanied by a considerable hissing and increase in static. Should the tube fail to oscillate with the volume condenser fully advanced, the filament rheostat should be turned up further. In the event that it should go into oscillation sharply or with disagreeable noises, it should be retarded to the point where oscillation can be accomplished with the soft "thud" mentioned. After oscillation is obtained, the wave band covered by the coil may be swept with the tuning condenser, always simultaneously manipulating the volume condenser in such a way as to keep the tube just on the verge of oscillation. On passing a broadcast signal, a distinct heterodyne whistle will be heard, which may be chopped up somewhat by the modulation carried by the signal. After locating the heterodyne point of the broadcaster, the "Volume" condenser is retarded somewhat until the tube is just out of oscillation. The setting of the tuning condenser is then corrected for maximum signal strength and it will then be found that the volume control can be advanced with some increase in signal strength up to the oscillating point of the tube.

In order to facilitate the location of stations whose wavelengths are known, the tuning chart shown in Fig. 1, has been prepared. It should be understood that this chart will vary somewhat with individual receivers due to small variations in coil and condenser characteristics as well as tube characteristics and wiring leads, but at any rate it will give those not familiar with the short wavelength stations a very definite idea of where to look for the experimental broadcasting station in which one is interested.



WHERE THE SHORT-WAVE BROADCASTS MAY BE FOUND

This chart shows the allocation of wavelengths from 10 to 70,000 kilocycles; the portions of the spectrum set apart for short-wave relay broadcasting and amateur work are clearly indicated

LIST OF PARTS

THE list of parts used in the construction of model illustrated here is given below. Other parts electrically and mechanically similar may be used, of course. It is not advisable to attempt the construction of the coils. The Aero kit comes as a unit, and at the present date it seems possible that the complete list of parts may be sold by the Aero Products company. Readers may obtain the manufacturer's constructional data and blueprints by writing to RADIO BROADCAST.

	(1)	Aero International Foundation Unit, complete with tube sockets and grid-leak mount.
L_1, L_3, L_5	(3)	Aero No. 60 choke coil.
L_2, L_4		Aero International Coil Kit.
C_3	(1)	Amsco 140-mmfd. short-wave condenser.
C_4	(1)	Amsco 250-mmfd. short-wave condenser.
C_1, C_5	(2)	Carter .005 fixed condenser.
C_6	(1)	Carter .0001 fixed condenser.
C_2	(1)	Carter .00015 fixed condenser.
C_7	(1)	Carter .001 fixed condenser.
R	(1)	Yaxley 10-ohm fixed resistor.
R_1	(1)	Yaxley 15-ohm fixed resistor.
R_3 & S	(1)	Yaxley 20-ohm No. 520 rheostat with switch and knob.
R_2	(1)	7-megohm grid-leak.
R_4	(1)	Yaxley 1-ohm fixed resistor.
T, T_1	(2)	Silver Marshal No. 240 audio transformers.
	(1)	Yaxley 7-prong plate.
	(2)	Binding posts (Antenna & Gnd.).
	(2)	Carter tip-jacks.
	(2)	National dials.

Accessories

	(1)	Yaxley cable connector
VT	(1)	cx-322 tube.
VT_1, VT_2	(2)	cx-301-A tube
VT_3	(1)	cx-312-A tube.
	(1)	6-volt storage battery.
	(1)	pair Trimm head phones (or loud speaker).
	(1)	9-volt C. battery.
		B-battery supplying 135 volts.

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by useing the coupon printed on this page. Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. RADIALL COMPANY.

2. HARD RUBBER PANELS—Characteristics and properties of hard rubber as used in radio, with suggestions on how to "work" it. B. F. GOODRICH RUBBER COMPANY.

3. TRANSFORMERS—A booklet giving data on input and output transformers. PACENT ELECTRIC COMPANY.

5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.

9. VOLUME CONTROL—A leaflet showing circuits for distortionless control of volume. CENTRAL RADIO LABORATORIES.

10. VARIABLE RESISTANCE—As used in various circuits. CENTRAL RADIO LABORATORIES.

12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.

15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.

15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.

16. VARIABLE CONDENSERS—A description of the functions and characteristics of variable condensers with curves and specifications for their application to complete receivers. ALLEN D. CARDWELL MANUFACTURING COMPANY.

17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION.

46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.

47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.

48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.

49. BYPASS CONDENSERS—A description of the manufacture of bypass and filter condensers. LESLIE F. MUTER COMPANY.

50. AUDIO MANUAL—Fifty questions which are often asked regarding audio amplification, and their answers. AMERTRAN SALES COMPANY, INCORPORATED.

51. SHORT-WAVE RECEIVER—Constructional data on a receiver which, by the substitution of various coils, may be made to tune from a frequency of 16,660 kc. (18 meters) to 1999 kc. (150 meters). SILVER-MARSHALL, INCORPORATED.

52. AUDIO QUALITY—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. SILVER-MARSHALL, INCORPORATED.

56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.

57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.

59. RESISTANCE COUPLING—A booklet giving some general information on the subject of radio and the application of resistors to a circuit. DAVEN RADIO CORPORATION.

63. FIVE-TUBE RECEIVER—Constructional data on building a receiver. AERO PRODUCTS, INCORPORATED.

70. IMPROVING THE AUDIO AMPLIFIER—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. AMERICAN TRANSFORMER COMPANY.

72. PLATE SUPPLY SYSTEM—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. AMERTRAN SALES COMPANY.

81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.

82. SIX-TUBE RECEIVER—A booklet containing photographs, instructions, and diagrams for building a six-tube shielded receiver. SILVER-MARSHALL, INCORPORATED.

83. SOCKET POWER DEVICE—A list of parts, diagrams, and templates for the construction and assembly of socket power devices. JEFFERSON ELECTRIC MANUFACTURING COMPANY.

84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.

85. FILTER—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. THE ABOX COMPANY.

86. SHORT-WAVE RECEIVER—A booklet containing data on a short-wave receiver as constructed for experimental purposes. THE ALLEN D. CARDWELL MANUFACTURING CORPORATION.

88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.

89. SHORT-WAVE TRANSMITTER—Data and blue prints are given on the construction of a short-wave transmitter, together with operating instructions, methods of keying, and other pertinent data. RADIO ENGINEERING LABORATORIES.

90. IMPEDANCE AMPLIFICATION—The theory and practice of a special type of dual-impedance audio amplification are given. ALDEN MANUFACTURING COMPANY.

93. B-SOCKET POWER—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. NATIONAL COMPANY, INCORPORATED.

94. POWER AMPLIFIER—Constructional data and wiring diagrams of a power amplifier combined with a B-supply unit are given. NATIONAL COMPANY, INCORPORATED.

101. USING CHOKES—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. SAMSON ELECTRIC COMPANY.

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.

23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.

26. DRY CELLS FOR TRANSMITTERS—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. BURGESS BATTERY COMPANY.

28. B BATTERY LIFE—Battery life curves with general curves on tube characteristics. BURGESS BATTERY COMPANY.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

32. METERS FOR RADIO—A catalogue of meters used in radio, with diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

36. CHARGING A AND B BATTERIES—Various ways of connecting up batteries for charging purposes. WESTINGHOUSE UNION BATTERY COMPANY.

37. WHY RADIO IS BETTER WITH BATTERY POWER—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.

53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.

69. VACUUM TUBES—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. RADIO CORPORATION OF AMERICA.

87. TUBE TESTER—A complete description of how to build and how to operate a tube tester. BURTON-ROGERS COMPANY.

92. RESISTORS FOR A. C. OPERATED RECEIVERS—A booklet giving circuit suggestions for building a. c. operated receivers, together with a diagram of the circuit used with the new 400-milliampere rectifier tube. CARTER RADIO COMPANY.

102. RADIO POWER BULLETINS—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the BH or B rectifier tubes. RAYTHEON MANUFACTURING COMPANY.

103. A. C. TUBES—The design and operating characteristics of a new a. c. tube. Five circuit diagrams show how to convert well-known circuits. SOVEREIGN ELECTRIC & MANUFACTURING COMPANY.

58. HOW TO SELECT A RECEIVER—A commonsense booklet describing what a radio set is, and what you should expect from it, in language that any one can understand. DAY-FAN ELECTRIC COMPANY.

67. WEATHER FOR RADIO—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. TAYLOR INSTRUMENT COMPANIES.

In sending the coupon below, make sure that your name and address are included and are plainly written.

USE THIS BOOKLET COUPON

RADIO BROADCAST SERVICE DEPARTMENT
RADIO BROADCAST, *Garden City, N. Y.*
Please send me (at no expense) the following booklets indicated by numbers in the published list above:

....

....

Name...

Address,...
(Number) *(Street)*

....
(City) *(State)*

ORDER BY NUMBER ONLY
This coupon must accompany every request. RB 7-28

73. RADIO SIMPLIFIED—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. CROSLEY RADIO CORPORATION.

76. RADIO INSTRUMENTS—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. JEWELL ELECTRICAL INSTRUMENT COMPANY.

78. ELECTRICAL TROUBLES—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage hatteries. Of interest to the owner of storage batteries. BURTON ROGERS COMPANY.

95. RESISTANCE DATA—Successive bulletins regarding the use of resistors in various parts of the radio circuit. INTERNATIONAL RESISTANCE COMPANY.

96. VACUUM TUBE TESTING—A booklet giving pertinent data on how to test vacuum tubes with special reference to a tube testing unit. JEWELL ELECTRICAL INSTRUMENT COMPANY.

98. COPPER SHIELDING—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. THE COPPER AND BRASS RESEARCH ASSOCIATION.

99. RADIO CONVENIENCE OUTLETS—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set. YAXLEY MANUFACTURING COMPANY.

105. COILS—Excellent data on a radio-frequency coil with constructional information on six broadcast receivers, two short-wave receivers, and several transmitting circuits. AERO PRODUCTS COMPANY.

106. AUDIO TRANSFORMER—Data on a high-quality audio transformer with circuits for use. Also useful data on detector and amplifier tubes. SANGAMO ELECTRIC COMPANY.

108. VACUUM TUBES—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tuhe. ARCTURUS RADIO COMPANY.

109. RECEIVER CONSTRUCTION—Constructional data on a six-tube receiver using restricted field coils. BODINE ELECTRIC COMPANY.

110. RECEIVER CONSTRUCTION—Circuit diagram and constructional information for building a five-tube set using restricted field coils. BODINE ELECTRIC COMPANY.

111. STORAGE BATTERY CARE—Booklet descrihing the care and operation of the storage battery in the home. MARKO STORAGE BATTERY COMPANY.

112. HEAVY-DUTY RESISTORS—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. WARD LEONARD ELECTRIC COMPANY.

113. CONE LOUD SPEAKERS—Technical and practical information on electro-dynamic and permanent magnet type cone loud speakers. THE MAGNAVOX COMPANY.

114. TUBE ADAPTERS—Concise information concerning simplified methods of including various power tuhes in existing receivers. ALDEN MANUFACTURING COMPANY.

115. WHAT SET SHALL I BUILD?—Descriptive matter, with illustrations, of fourteen popular receivers for the home constructor. HERBERT H. FROST, INCORPORATED.

104. OSCILLATION CONTROL WITH THE "PHASATROL"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. ELECTRAD, INCORPORATED.

116. USING A B POWER UNIT—A comprehensive booklet detailing the use of a B power unit. Tahles of voltages—both B and C—are shown. There is a chapter on trouble-shooting. MODERN ELECTRIC MFG. CO.

117. BEST RESULTS FROM RADIO TUBES—The chapters are entitled: "Radio Tubes," "Power Tubes," "Super Detector Tuhes," "A. C. Tubes," "Rectifier Tubes," and "Installation." GOLD SEAL ELECTRICAL CO.

118. RADIO INSTRUMENTS, CIRCULAR "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. WESTON ELECTRICAL INSTRUMENT CORPORATION.

120. THE RESEARCH WORKER—A monthly bulletin of interest to the home constructor. A typical feature article describes the construction of a special audio amplifier—AEROVOX WIRELESS CORPORATION.

121. FILTER CONDENSERS—Some practical points on the manufacture and use of filter condensers. The difference hetween inductive and non-inductive condensers. POLYMET MFG. CORP.

122. RADIO TUBES—Specifications and operating characteristics of vacuum tubes. Twenty-four pages. E. T. CUNNINGHAM, INC.

123. B SUPPLY DEVICES—Circuit diagrams, characteristics, and list of parts for nationally known power supply units. ELECTRAD, INC.

124. POWER AMPLIFIER AND B SUPPLY—A booklet giving several circuit arrangements and constructional information and a combined B supply and push-pull audio amplifier, the latter using 210 type tubes. THORDARSON ELECTRIC MFG. CO.

125. A. C. TUBE OPERATION—A small but complete booklet describing a method of filament supply for a.c. tuhes. THORDARSON ELECTRIC MFG. CO.

126. MICROMETRIC RESISTANCE—How to use resistances for: Sensitivity control; oscillation control; volume control; regeneration control; tone control; dete tor plate voltage control; resistance and impedance coupling; loud speaker control, etc. AMERICAN MECHANICAL LABORATORIES.

127. VITROHM NEWS—A monthly bulletin dealing with the resistance problems of the home constructor and experimenter. WARD LEONARD ELECTRIC CO.

128. SANGAMO CONDENSERS—A helpful table for converting capacities from microfarads to micromicrofarads. SANGAMO ELECTRIC CO.

129. TONE—Some model audio hook-ups, with an explanation of the proper use of transformers and chokes. SANGAMO ELECTRIC CO.

130. SCREEN-GRID AUDIO AMPLIFICATION—Diagrams and constructional details for remodeling old audio amplifiers for operation with screen-grid tubes. THORDARSON ELECTRIC MFG. CO.

SM

New! Short Wave Set!

Public Address Amplifier!

"Round the World Four"

AND now—an entirely new type of short wave receiver is ready, incorporating all of the sound engineering principles and advanced developments that have made S-M the most popular quality parts today. Heralding Silver-Marshall's definite entry into the short wave field, the new "Round the World Four" and "Round the World Adapter" introduce advanced features and an entirely new design technique. This set, the first to include screen grid R. F. amplification with one-dial tuning for a range of 17.4 to 204 meters, is simply irresistible. Completely shielded in a thick aluminum cabinet, it can be had as a two-tube tuner to adapt any standard set to short wave reception, or as a complete 4-tube set with loud speaker range of half way round the world and back.

These new S-M short wave sets are the first to be offered designed especially for broadcast and phone reception primarily, and for code secondarily. They alone have the smooth regeneration control that provides the enormous sensitivity necessary to long distance voice and music reception—yet they are absolutely non-radiating.

If you're after the thrill of real, world-wide DX, the "Round the World Four" is the set for you. Amateur station 9VS reported loud-speaker reception from six *continents* in an evening. Station 9BBW, operating the set, conducted amateur two-way communication with Germany, France, England, and Italy in one evening. In daylight, east and west coast amateur stations are heard in Chicago—Nauen, Germany, and England come in like locals. Five, ten, fifteen, and fifty-watt amateur telephones all over America and Canada are regular reception on the "Round the World Four."

Type 730 "Round the World Four" kit, ready to assemble, including all parts and cabinet just as illustrated, is $51.00. Type 731 is the two-tube "Round the World Adapter" kit, to adapt any broadcast set to long distance short wave reception, and is priced at $36.00 complete, with identical aluminum cabinet. Price, 131T, -U, -V. and -W. coils, tuning from 17.4 to 204 meters, $1.25 each, or $5.75 for set of four plug-in coils with 512 socket. Type 130 winding forms cost but 50 cents each. Type 732 "Round the World" essential kit includes all above coils, coil socket, .00014 tuning condenser, .00035 tickler condenser, and three R. F. choke coils, with complete instructions, $16.50.

685 Public Address Unipac

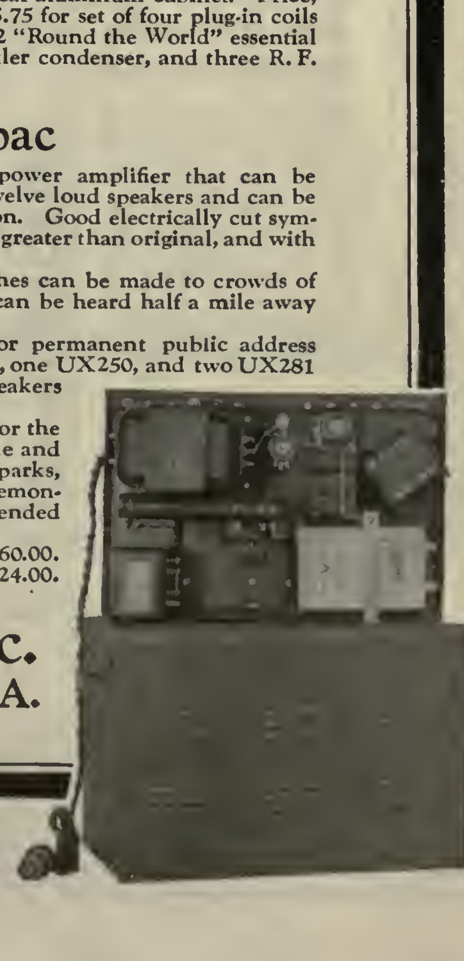
THE S-M type 685 Public Address Unipac is a high power socket-power amplifier that can be heard by from 2,000 to 30,000 people at once. It will operate one to twelve loud speakers and can be used interchangeably for voice, phonograph record or radio amplification. Good electrically cut symphony orchestra or jazz band records will be reproduced at volume equal to or greater than original, and with tone both natural and perfect.

Using the microphone, clear, understandable announcements or speeches can be made to crowds of 5,000 to 10,000 people, either indoors or outdoors. Record or radio music can be heard half a mile away on clear days.

Type 685 Unipac fills a long-felt want for an economical portable or permanent public address amplifier. It is complete in itself, requiring only one UX226, one UY227, one UX250, and two UX281 tubes and connection to a 110 volt, 60 cycle lamp socket for operation. Any speakers may be used, with any microphone, radio set, or magnetic record pick-up.

With political conventions, sporting events and elections coming on, for the wide-awake experimenter there is a wide and profitable market, both in sale and rental, to conventions, lodges, clubs, theatres, schools, churches, amusement parks, dance halls, and many other places. For thoroughly high quality outdoor demonstrations the 685 Unipac has no equal. (685 Unipac is not suited to nor intended for home use.)

Price, factory assembled, ready to use, less tubes and accessories, $160.00. Type 685 Kit, ready to assemble, with complete instructions, is priced at $124.00.



SILVER-MARSHALL, Inc.
870 W. Jackson Blvd., CHICAGO, U. S. A.

For 6c in stamps, complete constructional data sheets will be mailed.

The *Radio Broadcast* LABORATORY INFORMATION SHEETS

THE RADIO BROADCAST Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4" x 6" filing cards, or in a notebook. The cards should be arranged in numerical order. In July, 1927, an index to all sheets appearing up to that time was printed. Last month we printed an index covering the sheets published from August, 1927, to May, 1928, inclusive.

All of the 1926 issues of RADIO BROADCAST are out of print. A complete set of sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Orders for the next set following can also be sent. Some readers have asked what provision is made to rectify possible errors in these sheets. In the unfortunate event that any serious errors do occur, a new Laboratory Sheet with the old number will appear.

—THE EDITOR.

No. 201 RADIO BROADCAST Laboratory Information Sheet **July, 1928**

Tube Life

EFFECT OF EXCESSIVE LINE VOLTAGE

THE life obtained from a vacuum tube depends very much upon the filament voltage at which it is operated, for voltages slightly above normal produce a marked decrease in life. This is true of all types of tubes, a. c. or d.c., storage-battery or dry-cell-operated. In a battery-operated receiver we are able to control the filament voltage applied to the tubes quite accurately and normal life is therefore generally obtained from the ordinary types of storage-battery or dry-cell tubes. In an a.c.-operated receiver, however, where the filament voltages are obtained directly from the power lines, the operator of the receiver has little or no control over the filament voltage applied to the a.c. tubes. Most filament transformers are designed for a line voltage of about 115 but in many communities, rural ones especially, voltages in excess of this are frequently encountered. This higher line voltage of course affects the output voltages of the filament transformer so that the tubes are subjected to a filament voltage above normal.

It is suggested that experimenters working on a.c.-operated receivers include in the circuit some device which will enable them to control the voltage applied to the filament transformer. In cases where the line voltage is found to vary considerably so that at times it is above normal and at other times normal or below normal, it will be preferable to include in the circuit a variable resistance in the primary side of the filament transformer having a value of about 25 ohms. In those cases where the line voltage is found to be above normal hut constant at this value, a fixed resistance may be placed on the primary side of the filament transformer to absorb tbe excess voltage so that the transformer receives its rated voltage or slightly less, for it has been found that a.c. tubes will generally give satisfactory service on somewhat less than the operating voltage at which they are rated.

When remedies for excessive line voltage, such as we have suggested here, are made use of, each case must be treated more or less individually, and when, as is usually the case, the line voltage is not constant, a manually controlled resistance may be essential. These facts have been appreciated by many receiver and parts manufacturers. It is probable that devices will soon be available to home constructors which when placed in the primary side of a transformer will automatically control the voltage actually applied to the receiver, so that the tubes will always receive rated voltage despite fluctuations in the actual line voltage.

No. 202 RADIO BROADCAST Laboratory Information Sheet **July, 1928**

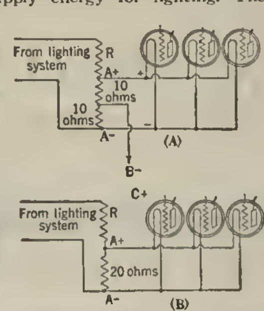
Farm Lighting Systems

AS A SOURCE OF FILAMENT CURRENT

THIS Laboratory Sheet is provided in response to requests from several readers for information on how to make use of power from a farm-lighting installation for the operation of the filaments of the tubes in a radio receiving set.

Farm-lighting systems are of two types, those using a generator powered by a gas engine in which the energy for the lights is obtained directly from the generator and those systems in which the generator is used to charge a bank of storage batteries which in turn supply energy for lighting. The voltages of these systems are generally either 32 or 110 volts.

To make use of this current in the radio receiver it is necessary to reduce the voltage by means of the resistance, *R*, the value of the resistance depending upon the number of tubes in the set and upon the voltage of the supply, as indicated below.



NO. OF TUBES IN RECEIVER	32 VOLT SYSTEM *R* IN OHMS	WATTS IN *R*	110 VOLT SYSTEM *R* IN OHMS	WATTS IN *R*
1	51	15	190	57
2	35	22	130	84
3	27	30	100	105
4	21	37	80	135
5	18	43	65	160
6	15	50	58	90
7	13	57	50	210
8	12	66	45	240

Two circuits are given, circuit B being the easier to use, but sometimes with this arrangement there may be some hum audible in the loud speaker. In such a case it is necessary to use circuit A.

With circuit B it is simply necessary to connect the resistance *R* in series with a 20-ohm resistor and connect the plus and minus A terminals to the corresponding terminals in the radio receiver.

Using circuit B the same changes must be made but in addition the B minus and C plus leads are removed from where they connect on the receiver and are connected instead to the center point of the 20-ohm resistor. When this arrangement is used the C voltages should all be increased by minus 3 volts to compensate the positive bias produced with the C plus and B minus leads connected to the center tap.

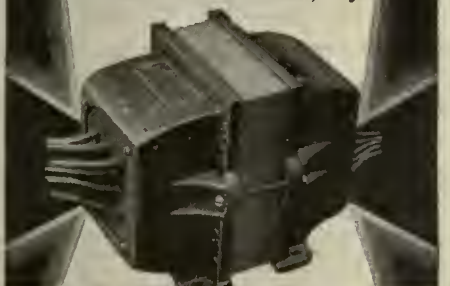
AMERTRAN PF-250
Power Transformer
for
UX 250 Power Tubes

A husky transformer built for doing the job, not for looks. The PF-250 is rated at 1200-600 volts plate, 7½ volts power tube, 7½ volts rectifier tube filament. Center taps are provided on each of the filament windings. Continuous rated capacity of plate windings, 160 MA., continuous rated capacity of each 7½ volt winding, 3 Amperes. DC plate output with two UX 281's full wave, up to 450 volts with sufficient excess for "C" Bias.

Ask for Bulletin No. 1033 describing fully the PF-250.

Price, each—$30.00
Slightly higher West of Rocky Mountains

American Transformer Co.
Transformer Builders for more than 28 Years
201 Emmet St., Newark, N. J.



AERO Corona Coil
Used in New
Cooley "Rayfoto"

Of course the new Cooley "Rayfoto" uses an AERO Inductance Coil. This special coil is designed to meet the exact specifications of A. G. Cooley, whose "Rayfoto" receiver so many experimenters will build. For every inductance requirement AERO Coils are proved best—by experts and amateurs as well. Always specify AERO Coils if you want the finest in radio performance.

AERO PRODUCTS, Inc.
1722 Wilson Avenue Chicago, Ill.

NATIONAL
CO. INC., *Announces*

A new precision Dial with type A Velvet Vernier Mechanism, German Silver face and precision Vernier, for Short-Wave Radio Use.

A new Short-Wave Condenser, built on the NATIONAL Girder Frame with pigtail and wide spacing for high voltages.

A new 2000 volt Transmitting Condenser, Pyrex Insulated.

Write us for Bulletin B-130

National Company Inc.
W. A. Ready, Pres. Malden, Mass.

QUALITY DONGAN PRODUCTS

Approved Parts
Transformers, Chokes and Condensers
For the
New UX #250 Power Amplifier Tubes

For the popular new UX #250 P. A. Tube Dongan laboratories have perfected a complete line of power unit parts. You can assure yourself of the maximum in performance with the proper Dongan parts, designed especially for use with this tube.

Illustrating No. 1177 Output Transformer. Chokes and Condensers are also mounted in matched cases similar to the one shown here.

Description of the Dongan Parts, used with the UX 250 Tube, is given in detail in this issue of Radio Broadcast.

#7568—A power supply transformer.
#1177—A straight power amplifier output transformer.
#1176—An output transformer for push pull amplification, designed for all types of dynamic speakers.

Condensers and Chokes for the complete Filter Circuits

Set Manufacturers and Custom Set Builders
You are invited to consult the Dongan engineering department for any desired information for your particular requirements. Production on all types assures satisfactory deliveries.

See our Exhibit—Booth 152—R. M. A. Show

DONGAN ELECTRIC MANUFACTURING CO.
2991-3001 Franklin Street
Detroit

TRANSFORMERS of MERIT for FIFTEEN YEARS

Helpful Technical Information

A regular feature of RADIO BROADCAST is the series of Laboratory Information Sheets, which cover a wide range of information of immediate value to every radio worker, presented in a form making it easy to preserve them. To insure your having every issue, send your check for $4.00 for one year's subscription, to

Subscription Department, Doubleday, Doran & Co., Garden City, N. Y.

RADIO PANELS
BAKELITE—HARD RUBBER
Cut, drilled and engraved to order. Send rough sketch for estimate. Our complete Catalog on Panels, Tubes and Rods—all of genuine Bakelite or Hard Rubber—mailed on request.

STARRETT MFG. CO.
521 S. Green Street Chicago, Ill.

Cardwell Condensers
ARE
RUGGED—
SIMPLE—
STRONG—

They are used and specified by the leaders—the Giants of Radio—not where a few pennies count in meeting competition, but when performance is a serious business and reputations are at stake. Need we suggest the reason?

RECEIVING CONDENSERS
TRANSMITTING CONDENSERS
Write For Literature or State Your Requirements

The Allen D. Cardwell Mfg. Corp.
81 Prospect Street Brooklyn, N. Y.
Dept. B

No. 203 RADIO BROADCAST Laboratory Information Sheet July, 1928

Tuned Circuts

CALCULATING EFFECTIVE RESISTANCE

LABORATORY Sheet No. 198 published in the June issue explained how to calculate the gain of a radio-frequency amplifier using a screen-grid tube. In calculating the gain we had to make use of the factor R which denoted the effective resistance of a tuned circuit at resonance. In this Sheet we will explain how this effective resistance is calculated.

A simple tuned circuit is indicated in the sketch and it can be proved mathematically that, at resonance, the circuit between points a and b acts like a high resistance with a value equal to

$$R = \frac{\omega^2 L^2}{r}$$

where

R is the effective resistance of the circuit at resonance as measured between points a and b

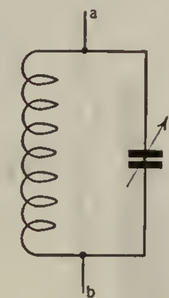
ω is equal to 2π times the frequency

L is the inductance of the coil in henries

r is the series resistance of the circuit.

The value r is the series resistance of the tuned circuit when actually connected in a tube circuit.

EXAMPLE: What is the effective resistance of a tuned circuit whose resonant frequency is 1000 kc. (300 meters), the series resistance of the circuit being 20 ohms and the inductance of the coil 0.25 millihenries (0.00025 henries)



$$R = \frac{(2\pi \times 1{,}000{,}000)^2\ (.00025)^2}{20}$$

$$= 115{,}000 \text{ ohms, effective resistance}$$

If this circuit were to be used in conjunction with a screen-grid tube the gain, calculated using the formula given in Sheet No. 198 would be:

$$\text{Gain} = G_m \times R$$
$$= 0.000350 \times 115{,}000$$
$$= 40$$

No. 204 RADIO BROADCAST Laboratory Information Sheet July, 1928

Line Voltage Variations

EFFECT ON TUBE LIFE

LETTERS from readers have been received by the Laboratory from time to time to the effect that the life of the 171 type tube used in their power unit was very short, sometimes lasting only about 100 hours. The normal life of a 171 type tube should be at least 1000 hours. The probable cause, in many cases, of such short life is excessive filament voltage.

The transformer in a power unit is designed generally to operate with a line voltage of 110 volts a.c. With this voltage across the primary the voltage across the filament terminals of the 171 type power amplifier should be 5 volts. If the voltage across the primary is less than 110 volts, then the voltage across the filament of the tube is less than 5 volts and conversely, with input voltages higher than 110 volts the voltage across the filament of the tube will be excessive, i.e., more than 5 volts.

If the filament voltage drops very much, the electronic emission from the filament will decrease and distortion of the signal will result. If, on the other hand, the filament voltage is excessive, the output of the system is not audibly affected and so with no audible indication of the excessive voltage, it is likely that it will go by unnoticed. It is excessive filament voltage which must be guarded against however, if a normal length of life is to be obtained from any tube.

The extent of the fluctuations in line voltage is, of course, different in different parts of the country—in large cities the voltage is generally quite constant, while in rural communities comparatively large variations in line voltage are probable.

These problems, brought about by inconstancy of line voltage, are becoming more serious as the use of a.c. operated receivers becomes more popular. In such receivers, all of the tubes are operated directly from the power line and decreased tube life due to excessive filament voltage is to be carefully guarded against.

The solution of these difficulties lies in the design of a device which will automatically control the voltage actually applied to a power unit. The type 886 tube is a device of the sort, designed to insure constant input to power operated radio receivers, despite fluctuations in line voltage. Several devices to accomplish regulation by other means are also being developed by other manufacturers and will probably be available shortly.

No. 205 RADIO BROADCAST Laboratory Information Sheet July, 1928

Electrical Measuring Instruments

THE GALVANOMETER

THIS is the first of a series of Laboratory Information Sheets to be devoted to the subject of electrical measuring instruments. In this Laboratory Sheet we discuss what is probably the oldest instrument for measuring current and voltage. This instrument is the galvanometer, and most of our modern ammeters and voltmeters are merely adaptations in one form or another of the galvanometer.

The galvanometer in its earliest form consisted of a compass needle suspended in the center of a coil of wire. When a current passed through the coil the compass needle was deflected from its normal position. It was termed a tangent galvanometer, for the current flowing in the coil is proportional to the tangent of the angle through which the needle is deflected. The tangent galvanometer is not very sensitive and, finding no practical use to-day, its major interest is historical.

Sir William Thomson (Lord Kelvin) did considerable work to improve the galvanometer and succeeded in developing an instrument of high sensitivity. Instruments made in accordance with his recommendations are known as Thomson galvanometers. Thomson made use of two coils in his galvanometer arranged to neutralize each other and found it possible to make the needle of the instrument move with only an exceedingly small current flowing in the coils. Galvanometers of this type have been made so sensitive that $\frac{1}{50}$-billion of an ampere would cause the pointer to deflect. A Thomson galvanometer, although very sensitive, has the disadvantage that in its simplest form it does not return to the zero point very quickly when the current flow through the coil is stopped and also the pointer oscillates back and forth for quite a long period of time before it finally comes to rest at any position. Thomson galvanometers can be made more satisfactory by attaching a vane to the suspension so that the air resistance created as the vane turns tends to bring the galvanometer to rest more quickly. This mechanical type of "damping" is the only type that can be applied to the Thomson galvanometer and for this reason another form of the instrument has come into more general use, known after its inventor as the D'Arsonval galvanometer.

In the Thomson galvanometer we had a stationary coil and a moving magnetic needle; in the D'Arsonval type we use a stationary magnet and a moving coil. The magnet is a very strong one and the coil moves in a small air gap in the magnetic circuit. The constructional features of such an instrument will be given in a Sheet to follow this.

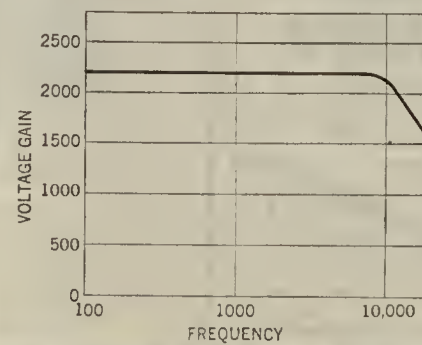
No. 206 RADIO BROADCAST Laboratory Information Sheet July, 1928

A Screen-Grid Resistance-Coupled Amplifier

ITS FREQUENCY CHARACTERISTIC

THE frequency characteristic of a resistance-coupled amplifier using screen-grid tubes is included on this sheet and indicates clearly the excellent quality which such an amplifier is capable of delivering. The screen-grid amplifier used in making this curve was described in the June, 1928, Laboratory Information Sheets Nos. 195 and 196.

The frequency characteristic which is obtained from an amplifier of this type depends upon several factors. One of the most important is the voltages at which the screen-grid tubes are operated. The power unit supplying the amplifier should be capable of delivering 135 to 180 volts and the screen-grid voltage should generally be 22½ although 45 volts is satisfactory if the 180 volts is used. This curve was made using 0.25-megohm plate resistors, 2.0-megohm grid resistors and 0.01-mfd. coupling condensers.



The high-frequency response of the amplifier would be poorer with higher values of coupling resistance because under such conditions the input and output capacities of the tubes, forming a shunt around the resistors, would produce a decrease in high-frequency response. The high-frequency response in this screen-grid amplifier is much better than is ordinarily obtained from a resistance-coupled amplifier using type 240 tubes. There is this to say, however, that the high-frequency response of this amplifier as indicated by the curve on this sheet is really better than it need be, for frequencies above 6000 or 7000 cycles do not contribute very much to the naturalness of the reproduction.

The low frequency response of the amplifier is determined by the size of the coupling condenser; the smaller the capacity the poorer the low-frequency response. The value of 0.01 mfd. which was used is evidently satisfactory judging from the curve, and probably values considerably smaller than 0.01 mfd. would also be satisfactory.

The high gain of this amplifier has some disadvantages which were pointed out in Laboratory Sheet No. 195 to which we refer the reader for further information.

No. 207 RADIO BROADCAST Laboratory Information Sheet July, 1928

Equalizing Wire Lines forBroadcasting

VALUES INVOLVED

IT IS obvious that the fidelity of reproduction obtained from a radio receiver cannot be any better than that transmitted by the broadcasting station and in discussing the subject it is therefore of value to know what frequencies are at present being transmitted by the better broadcasting stations. Some data on this subject was published in the article by C. E. Dean in the June, 1928, RADIO BROADCAST.

What frequencies are transmitted by broadcasting stations depends, among other things, upon the audio-frequency characteristics of the apparatus—microphones, amplifiers, modulators—used at the broadcasting station and upon the characteristics of the wire lines used to connect the broadcasting studio with the transmitter. Many of the better transmitting stations are now located outside of cities and therefore must use a wire connection between the transmitter and the studios located within the city. At the present time the characteristic of the wire lines is very important in determining what audio frequencies will finally be impressed upon the carrier wave.

The wire lines used with the broadcasting stations are at present equalized, that is made to transmit equally well, frequencies from 100 cycles to 5000. The characteristic of these lines below 100 cycles is probably quite good, but in no case can it be certain that a station is actually transmitting any frequencies, at their proper amplitude, below about 100 or above about 5000.

It is certain that as better loud speakers become available capable of reproducing frequencies below and above the limits given above that higher and lower frequencies will be included in the transmissions of broadcasting stations. In fact we may expect that the characteristics of the wire lines will be improved even before such loud speakers are generally available. The Telephone Company controlling the wire lines has always followed a policy of being prepared to furnish lines better than are actually essential at the time, considering the quality of the remainder of the apparatus included in the link between the microphone in the studio and the loud speaker at the listener's home.

A wire line ordinarily tends to transmit the lower frequencies much better than the higher frequencies and it is therefore the function of the equalizer to lower the high-frequency response so that a flat characteristic is obtained over the entire band.

No. 208 RADIO BROADCAST Laboratory Information Sheet July, 1928

Power Values in Radio Receiving Antennas

RELATION OF DISTANCE AND MEASURED RECEIVER VOLTAGE

IT IS interesting to compare the amount of power ordinarily intercepted by a radio receiving antenna with the power which is required to operate an ordinary 60-watt incandescent lamp, for example. In Professor Morecroft's book, *The Principles of Radio Communication*, some figures are given for the amount of current in a receiving antenna which had a resistance of about 60 ohms. In the figures which he gives for received antenna current, we find that when the receiver was located about a mile from the particular transmitter which was used (the power rating of the transmitter is not given) that the current in the receiving antenna was approximately 70 microamperes. If we square this current and multiply it by the resistance of the receiving antenna which is 60 ohms, we obtain the power in the receiving antenna, which proves to be approximately 3×10^{-9} watts. For those who do not realize what this exponent signifies, the power specified in the orinary way is

0.000000003 watts

The power required to operate an ordinary electric light bulb is 60 watts. Therefore the power required by the electric light would be sufficient to supply antenna power to operate approximately twenty billion radio receivers each requiring 70 microamperes of current in the receiving antenna as specified above.

The figures given at the end of this Laboratory Sheet, which have been taken from Morecroft, also indicate that the amount of power in the receiving antenna varies approximately inversely with the distance between the transmitter and the receiver. At a distance of 100 feet the received current is twice as great as when the separation is 200 feet. The power is proportional to the square of the current and therefore a ratio of two in current means a ratio of four in power. Twice the distance therefore gave one fourth the power.

DISTANCE IN FEET BETWEEN ANTENNAS	CURRENT IN RECEIVING ANTENNAS (MICROAMPERES)
100	12320
200	6435
300	4548
400	3108
1260	715
2420	283.5
3700	105
4600	96.5
6220	69.5

Letters From Readers

Direct Selling on the Air

THE president of the Iowa Radio Listeners' League, Francis St. Austell, described in RADIO BROADCAST for May, direct radio selling which assails the ears of listeners out Iowa way. The letter below, from a reader in Burlington, Iowa, is interesting as the opinion of a listener located in the center of things.

To the Editor;

Permit me to say that I read RADIO BROADCAST regularly, and have, in fact, almost since it was established. I have many clippings from it and among my most valued, is a complete file of "Laboratory Sheets," which I have accumulated from my own copies of R. B. I am heartily in sympathy with your editorial policy.

I read, with much interest, Mr. St. Austell's article. Being out here in the heart of the "direct selling" area, I may speak accurately. That was a "warm" session in Des Moines, too. I am not interested in direct selling, either for or against. I am only interested in merchandising as everyone interested in the social structure should be. But I have no direct connection with it.

First, I have never heard any outstanding values offered over the radio. True, I do not consistently listen to those stations, but I do occasionally drift into them when the better stations are off the air. But I am impressed with their statements about the merchandise, when goods of equal or superior quality may be bought at retail in our own city at corresponding prices. But I am impressed with the carelessness with which the truth is handled. I believe a half truth often more misleading than an entire falsehood.

For instance, during the time when the increased postal pay and rate bill was pending, I heard Mr. Field address his radio audience asking them to write their senators and representatives urging them to vote against the bill, telling them it would surely mean greatly increased parcel post rates. The increase was actually two cents per parcel, I believe, and regardless of the merits of the bill, I do not believe it was parcel post rates, but rather the increased cost of circular mailings that worried Mr. Field.

I took occasion to write Mr. Field once criticizing his broadcast on some occasion and received in reply—*a seed catalogue*. And I have received them regularly since then!

Mr. Baker of KTNT makes statements which are possible of several interpretations. So does Mr. Henderson, KWKH, not a seller. I once wrote Mr. Henderson questioning some statement. His reply was to the effect that he regretted that I did not agree with him—that less than six in a thousand letters received by him were uncomplimentary. No answer to my criticism at all. Maybe the people who would write uncomplimentary letters just don't write.

I've played with wireless since along about 1912. And short waves since amateurs were forced on them. And I've listened to Baker harp on Monday nights about opening up short-wave channels to broadcasting. He is squawking now about the short wave he is on. Why not open up, say 50 meters, and ask him to take it! Obviously, short-waves are all right—for someone else. I read your articles on this subject with much interest.

Direct selling, no doubt, does offer undue advantage. Seems to me the solution would be organization of legitimate business men. But I would like to see the Radio Commission out of politics, unhampered, with equal authority to enforce their dicta and a censorship authority of some sort that would make station owners and announcers adhere rigidly to facts.

Why should it be possible to say over a radio anything that could not be printed in a newspaper or magazine? Yet they can say anything they choose and get away with it.

Anyone with a reasonably good receiver can choose his own programs. Of course, there are a lot of people in, for instance, Muscatine, who must listen to Baker's ravings, or nothing. He is located in the heart of the city, with almost enough power to blanket the average five-tube set any place in the city.

It appears to me that the real solution would be to close up about 150 or 200 of the last ones licensed. Of course, a few good ones would have to go. But what other equitable arrangement could be made rather than closing the last ones licensed? Probably WJAZ ought to be closed because they were perhaps more nearly entirely responsible for the present condition than any other one thing.

But I'm surely with you. And may it all get out of politics, yet, before it is entirely doomed to oblivion.

SMITH TRUMP, Burlington, Iowa.

"Fading" Due to Street Cars

MR. A. H. Klingbeil of Ashtabula, Ohio, writes as follows:

To the Editor;

Commenting on your April issue. In "Strays" from the Lab. the mentioned street car effect in a receiver has been noticeable for a long time at my home. While I have never checked the action for data, I have noticed that some stations faded completely while street cars were passing the house for perhaps 50 or 75 feet either side or a total distance of about 200 feet maximum, and on other occasions, the street car effect was to "increase" the volume temporarily of the station tuned-in.

My antenna is approximately 125 feet straight in from pole in rear, at approximate trolley wire height, also street car feeder wires, power wires, arc lamp circuit, on same poles in front of my residence. Antenna is at right angles to street wires. There are no stations within 50 miles of my location and the ones fading or increased by street car action have been farther away than that and with receiver adjusted to low volume.

House supply wires lead-in to same room where the set is, and interior wires parallel the antenna for 15 feet, four feet apart. Until two weeks ago I used a waterpipe ground, later a drilled well ground, and last two weeks a chemical B power unit requiring no receiver ground, and effects seem to be the same, but not on all stations at any of the time past or present.

One of the first receivers I owned was a Fada 160 and at that time a suburban electric line operated a 1:30 A.M. car into Ashtabula from a distant point; no other cars operated at this hour. I usually could hear the "motor whine" for some minutes before the car arrived when I was listening to a weak station.

The Popular R. B. "Lab" Circuit

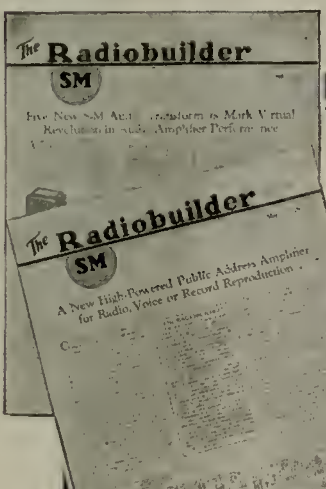
READERS have written in great numbers reporting their results with the R. B. "Lab" circuit. This was described first in our June 1926 and in November, and December 1926 and January and February, 1927. The receiver was redesigned with more modern parts, and in our April, 1928, issue Keith Henney described measurements on the set, showing how it was designed and the results achieved. Among the many letters which came in the following is of interest.

To the Editor;

I built the Lab circuit from your schematic diagram in the April 1928 issue and am immensely pleased with it. I live in a fearful radio locality: West 76th street, New York; no antennas permitted on the apartment building, and direct house current, so you may imagine what I am up against. For my antenna, I drop a wire out of the window and get splendid local reception.

JOSEPH C. EGGART, New York City.

SM S-M LEADERSHIP means Better Radio



Are you receiving THE RADIOBUILDER regularly? This little house magazine is printed occasionally to provide you with new and advance information on forthcoming S-M developments, and to pass along operating hints and kinks that will help you to get the most out of radio building. Issues, numbers one and two, pictured above are good examples of what THE RADIOBUILDER contains—a practical description of the first light socket public address amplifier available for home construction, and the inside, advance story on the practical phases of the new Clough audio system, with all curves.

THE RADIOBUILDER is newsy, and timely, and, above all, it is the condensed, monthly key to all the detailed constructional data you desire, for in it are listed and previewed all new S M DATA SHEETS each of which can be had for a two cent stamp.

Fill out the coupon below if you'd like to keep abreast of new radio developments.

If you want a veritable mine of Radio information, fill out the coupon and it's yours!

Silver-Marshall, Inc.
838 -W. Jackson Blvd., Chicago, Ill.

Enclosed find........in stamps for which please send me

......(50c) next 12 issues of THE RADIOBUILDER, or

......(1.00) next 25 issues of THE RADIOBUILDER

Please send me the following S-M DATA SHEETS, at 2c each:

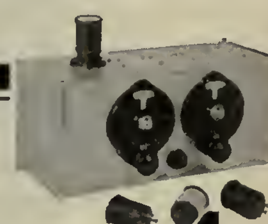
......No. 1—670B—670ABC RESERVOIR POWER UNITS

......No. 2—685 PUBLIC ADDRESS UNIPAC

......No. 3—730, 731, 732 "ROUND THE WORLD" SHORT WAVE SETS

......No. 4—HOOKUPS FOR 223, 225, 226, 255, and 256 AUDIO TRANSFORMERS.

.........I am a professional setbuilder. I am interested in your Authorized Service Station plan.



IN four short years Silver-Marshall, Inc. has forged up from obscurity to the position of dominant leadership in the radio parts and kit field—interesting, you say, but just what does that mean to *you?*

S-M leadership means just one thing—better radio for less money. Ask any one of the thousands upon thousands who enjoy radio to the full thru S-M kits and circuits. Ask the multitude of experimenters who have literally used and recommended S-M into first place; who two years ago swept S-M audio transformers into unquestioned leadership thru a veritable avalanche of approving purchases and who have held S-M audios at the top ever since. Ask the thousand odd Authorized S-M Service Stations who have built a profitable business and satisfied customers on S-M stability and worth. Or ask the dealers and jobbers who have seen S-M rapidly crowd competitors from their shelves, to become in four seasons the largest selling, most profitable parts line.

They'll all tell you that S-M leadership means better radio at less cost.

And S-M will lead again in 1928 and 1929 by giving you new developments that enable made-to-order or home-built radio sets to equal in external finish the finest factory productions, parts that place the performance of such sets utterly beyond competition, and, thru knock-down kits, radio receivers that will consistently and positively outperform all ready-made sets at anywhere near their amazingly low prices.

New S-M Offerings

The 720 Screen Grid Six, a six-tube dual control screen grid receiver kit at $69.75 complete with all-metal assembly, individual stage shielding, and averaging 10 KC selectivity against powerful locals—a set that brings in forty to a hundred stations in one evening. This set can be had for A.C. operation at $74.00 for 171, 210 or 250 power tubes.

And at $49.75 S-M offers the 740 "Coast to Coast" Screen Grid Four—a kit that is a revelation in four-tube results. Type 700 metal shielding cabinet as illustrated is but $8.50 additional, for either set, finished in attractive duo tone brown. It gives to each a new standard of style and distinction.

The Sargent-Rayment Screen Grid Six, type 710, is the wonder set of the season, and S-M offers, exclusively, the approved kit at $120.00. It is complete with aluminum shielding cabinet and will bring in 100 stations on any average evening.

The S-M "Round the World" Short Wave sets are the trimmest, most efficient short wave sets yet, priced from $36.00 to $51.00 complete with shielding cabinet. New S-M condensers are marvels of rigidity and flexibility in Universal single, and triple types. The 685 Public Address Unipac—the first really high-powered amplifier yet offered—is priced at only $160 wired, or $124 for the kit. It will turn out music or voice that can be heard by 1000 to 10,000 people.

Of course, the most startling audio development of the last two years would logically come from S-M laboratories, as it did two years ago. The new Clough audio transformers have been deservedly the sensation of the June radio trade show. In open comparative tests S-M 255 and 256, $6.00 transformers have excelled the performance of all competitive types tested, regardless of cost. The 225 and 226 transformers at $9.00 each simply leave the most skeptical marveling.

These and many other startling new S-M parts leave small wonder at S-M leadership. They prove that *you* can get the best radio for the least cost from S-M.

SILVER MARSHALL, Inc.
838 —W. Jackson Blvd., Chicago, Ill.

RADIO BROADCAST

AUGUST, 1928

WILLIS KINGSLEY WING, Editor

KEITH HENNEY
Director of the Laboratory

EDGAR H. FELIX
Contributing Editor

Vol. XIII. No. 4

CONTENTS

The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

AMONG OTHER THINGS. .

TELEVISION, for the moment, appears to be drawing perhaps more than its just share of attention. Our leading article in the July number explained some of the most serious limitations of television systems and pointed out the greatest obstacles which are yet to be overcome. In this issue, Mr. Clarkson discusses the results which can be had from some of the systems which may be before the public. If RADIO BROADCAST does not rush into print with "constructional" articles on television sets, our readers may forgive us. We strongly doubt that even the most enthusiastic of experimenters will be content with the results he can achieve from the transmissions now taking place. Television, we fear, is now rather a glittering idea than an accomplished fact. As the apparatus made available to the experimenter improves, we shall publish instructions on how to use it. It should be noted that the transmission of television signals on broadcast frequencies now seems to offer definite limitations in quality. The short waves—already nearly overcrowded with other services—offer the only possibility, both in still and motion picture transmissions, for improved quality (unless some new system is developed), and it is our belief that they should be employed at the start of our technical gropings in this field.

ONE hears the argument that if only the experimenter is permitted to investigate television—and still picture transmission—the play of his ideas will hasten the day when seeing by radio at a distance is general. It is certain that almost everyone, except those who are technically informed, feels that radio motion pictures, in sufficient detail and size to be comparable with good fidelity and volume in broadcast reception, are shortly to be attained. Attained in some mysterious way, like the radio transmission of power, for example. Television apparatus thus far shown is little more than a laboratory toy, remarkable perhaps, but still a toy. And, while the tightly closed doors of large laboratories may even now contain experimental secrets which will in time smooth the way, so far as the published facts go, television is still a laboratory matter.

THE Trade Show recently concluded at Chicago offered nothing startling. The complete sets presented showed some features of interesting design—a six-tube battery operated set consuming 8 mA. in plate current, for example. There was no great stir over automatic or semi-automatic tuning control as offered in some receivers. The parts and accessories presented were of better design and were lower in price. It is quite apparent that the set builder in the coming season can choose from highly satisfactory apparatus, can assemble it at a low cost, and the result will be not only a good-looking set of fine performance, but one which will compare favorably in cost with completely assembled sets. Every maker, it seems, has a dynamic type loud speaker, many of which are excellent.

A REGRETTABLE error occurred on page 128 of the July number of RADIO BROADCAST, in the article, "What Hope for Real Television?" The captions for the two diagrams on this page were reversed. The diagram at the upper left is the Clarkson television camera, and that at the lower right the television projector.

—WILLIS KINGSLEY WING.

DOUBLEDAY, DORAN & COMPANY, INC., Garden City, New York

MAGAZINES

Country Life
World's Work
Garden & Home Builder
Radio Broadcast
Short Stories
Educational Review
Le Petit Journal
El Eco
Frontier Stories
West
The American Sketch

BOOK SHOPS (Books of all Publishers)

New York: Lord & Taylor; James McCreery & Company; Pennsylvania Terminal and 166 West 32nd St.; 848 Madison Ave. and 51 East 44th Street; 420 and 526 and 819 Lexington Avenue; Grand Central Terminal and 38 Wall Street
Chicago: 75 East Adams Street
St. Louis: 223 N. 8th St. and 4914 Maryland Ave.
Kansas City: 920 Grand Ave. and 206 West 47th St.
Cleveland: Higbee Company
Springfield, Mass: Meekins, Packard & Wheat

OFFICES

Garden City, N. Y.
New York: 244 Madison Avenue
Boston: Park Square Building
Chicago: Peoples Gas Building
Santa Barbara, Cal.
London: Wm. Heinemann, Ltd.
Toronto: Doubleday, Doran & Gundy, Ltd.

OFFICERS

F. N. Doubleday, *Chairman of the Board*
Nelson Doubleday, *President*
George H. Doran, *Vice-President*
S. A. Everitt, *Vice-President*
Russell Doubleday, *Secretary*
John J. Hessian, *Treasurer*
Lillian A. Comstock, *Ass't Secretary*
L. J. McNaughton, *Ass't Treasurer*

TERMS: $4.00 a year; single copies 35 cents.

Increase your radio enjoyment

BY replacing each tube in your set with a *new* Cunningham Radio Tube you are sure of clear, resonant tone. You are virtually giving new life and energy to your radio, and you thereby increase your radio enjoyment.

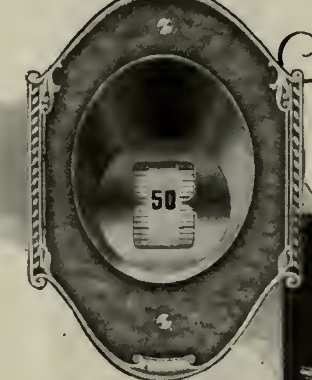
Don't use old or inferior tubes with new ones—use new tubes throughout.

Look for the name CUNNINGHAM *on the Orange and Blue carton*

E. T. CUNNINGHAM, Inc.
New York Chicago San Francisco

Cunningham RADIO TUBES

HAMMARLUND *Presents a New* Knob-Control DRUM DIAL



A richly embossed oxidized bronze escutcheon of exclusive design and graceful proportions. Figures and graduations are illuminated from the back.

Back View

Note position of the Control Knob. By using a Condenser Shaft of suitable length, the Control Knob may be placed at any desired distance from the dial, thus giving a pleasing balance to the front of the panel.

HAMMARLUND now offers a new illuminated drum dial of unusual beauty, rugged design, and distinctive mechanical features.

It is controlled by a knob, cleverly planned to be placed in any position on the panel, desirable for attractive balance.

The driving mechanism utilizes an exceptionally strong silk and linen cord, gripping a drum, snubber fashion. It cannot slip—absolutely no backlash or lost motion.

Thoroughly tested for wear under actual working conditions, this cord withstood 36,600 full-range movements of a large multiple condenser without stretching, fraying or breaking. It will never receive similar treatment in average use.

The original Hammarlund two-finger-control Drum Dial, introduced last season, will be be supplied for those preferring that type.

If your Dealer can't supply you, write direct to us. Ask for Hammarlund literature.

HAMMARLUND MANUFACTURING COMPANY
424-438 W. 33rd St.
New York

For Better Radio
Hammarlund PRECISION PRODUCTS

BROWNING-DRAKE

Plans for the coming season are now ready for dealers. A wonderful new line of receivers, loud speakers and kit parts has just started Browning-Drake on its greatest year.

BROWNING-DRAKE CORP.
CAMBRIDGE, MASS.

AERO Corona Coil

Used in New

Cooley "Rayfoto"

Of course the new Cooley "Rayfoto" uses an AERO Inductance Coil. This special coil is designed to meet the exact specifications of A. G. Cooley, whose "Rayfoto" receiver so many experimenters will build. For every inductance requirement AERO Coils are proved best—by experts and amateurs as well. Always specify AERO Coils if you want the finest in radio performance.

AERO PRODUCTS, Inc.
1722 Wilson Avenue Chicago, Ill.

Radio Brings the Stock Exchange to the Wilderness

At Bow Lake, in the Canadian Rockies, the portable receiver carried by Lewis R. Freeman, on the Harmon-Freeman Expedition of 1924, brought in United States and Canadian stations from coast to coast. This picture shows Mr. Freeman typing off the broadcast quotations from the San Francisco Stock Exchange. On one occasion, when these quotations indicated a movement in a certain stock, Mr. Freeman sent an order to his broker by carrier pigeon which resulted in a substantial profit. The portable set used, though it was banged about and even submerged in water on occasions, functioned admirably for the whole trip.

HE PLANS TELEVISION FOR WRNY

Theodor Nakken is shown here with a television receiver designed to receive the television broadcasts from WRNY. *The Nipkow disc and its driving motor are set at an angle, and the sloping panel which covers the front of the receiver has a small window through which the images are viewed.*

What Can We See By Radio?

By R. P. Clarkson

Author of "The Hysterical Background of Radio"

MORE and more the most enthusiastic radio fans are wondering what all the shooting is about. They realize that true television is not here but it is apparent that something is happening. Just what is being done, how it is being done, and what any fan can do to be "in the swim" is the purpose of this article in RADIO BROADCAST.

First of all, the fan will come to realize that he faces a new handicap. He has been used to twirling the dials and getting one program as easily as another. The set that reproduces any music from WGY will also give any music played at WRNY. Now, he is to find that while he may tune-in on the pictures from either station, the television receiver which works on WGY's experiment won't do a thing on WRNY, and vice versa. This, it seems to many of us, is particularly unfortunate at the beginning of the new pastime, particularly as there is no reason for this condition except the whim of the sender or the desire of the manufacturer to be exclusive.

The heart of all present television devices is the Nipkow disc, which dates back to 1884. It is a rotating plate with a series of spirally arranged holes; aluminum is the material generally used for the disc. The speed of the disc is always determined by the number of pictures sent per second. This speed is capable of variation, of course, because the disc is driven by an electric motor and the motor speed can always be changed. In the commercial devices I have seen, however, there is no provision made for any considerable speed change. The fan who builds his own device can insert a speed control to advantage.

A PICTURE $1\frac{1}{4}$ INCHES SQUARE

NOW, as to the size of the picture, nobody needs to ask what size is being transmitted. It makes no difference to the receiver so long as the picture is square. Your receiving projector can be arranged to give you any size your heart desires, *limited only by the size of the illuminated plate in the neon receiving lamp*. The Raytheon type of neon lamp with $1\frac{1}{2}''$ plates will safely cover a picture image $1\frac{1}{4}''$ square. Probably no manufacturer will go much larger. Commercial receivers now planned are of that size or smaller, although at least one will put a magnifying lens in front of the viewing plate. This will enlarge the image and decrease the quality but make the picture more easily seen by a group.

While the plate of the neon tube will absolutely limit the maximum picture size you can *get*, the spacing of the holes in the spiral disc and the pitch of the spiral will determine what size picture is actually *projected* at the receiving end. That is, if the holes are spaced one inch apart and the inner hole is one inch nearer the center of the disc than the outer hole, your picture will be one inch square. The spacing of the holes determines the width of the picture. The pitch of the spiral determines the depth of the picture. The size of the holes themselves is automatically determined by the size of the picture you want and the number of "lines" to the picture. Divide the depth of the picture by the number of lines transmitted and the result will be the diameter of the holes. Preferably, they will be a few thousandths of an inch larger than this calculation gives, so that each line will overlap the preceding one very slightly.

These technical details are all that distinguish one apparatus from another. First, the speed of the disc, which must turn each second the same number of times as there are pictures per second transmitted. Second, the number of holes in the spiral, which must be equal to the number of lines per picture transmitted. These two facts must be known, and undoubtedly will be published by each station as it takes up television transmitting. At present, WGY sends 24 lines per picture and 21 pictures per second. WRNY will send 36 lines per picture and 10 pictures per second. Hence, the speed for a disc to receive WGY must be 21 revolutions per second or 1260 r.p.m. For the Nakken pictures from WRNY there must be a disc speed of 10 revolutions per second or 600 r.p.m. On the other hand the WGY disc will have 24 holes in a spiral while the Nakken disc will have 36 holes. For the same size of picture, therefore, the Nakken disc must be larger, but it goes at half the speed and will give better definition.

Of course, if you can vary the motor speed 100 per cent. through the range of 600 r.p.m to 1260 r.p.m., the substitution of discs will let you receive either station at will. Or, it is possible to have two sets of holes in the same disc. The spirals may be concentric and the speed changed, or a large disc used and the WGY spiral placed only half way round, with two such spirals for each disc, and the WRNY spiral all the way round. The disc would then need a speed of about 600 r.p.m. to receive either number of pictures. These matters will be brought out in various constructional articles and are mentioned here only to indicate the details in which one receiver will differ from another. The point is that it is only in the disc that any distinct difference will lie between the various television systems, with the exception of the Baird arrangement—and he will probably come to this sooner or later, just as Jenkins and Alexanderson have.

NEON TUBES FOR SALE!

This window display in New York's Radio Row offers the television fan neon tubes at the modest charge of fifty-five cents, and a glimpse at a distinctly experimental set-up for television reception. The size of picture possible may be judged from the opening in the board behind the magnifying glass. Obviously the magnifying glass is a very necessary part of the set-up

WHO IS DOING THE WORK?

THE roll of sponsors for television apparatus at present include Nakken, who is manufacturing; Jenkins, who is negotiating with a view to manufacturing; Baird, who has interested American manufacturers; Alexanderson, whose firm seems at present only interested in broadcasting pictures experimentally at WGY; and a Boston group of experimenters who announce that WLEX will be on the air with pictures before long. Nakken will use WRNY.

While all the other devices use simple neon lamps in the set output instead of (or in series with) the loud speaker, the lamp being viewed through the holes of a rotating Nipkow disc, Baird has been using a lamp, a Nipkow disc, a slotted disc, another disc, a mirror, and a collection of prismatic cells at the receiving end. At present this assorted collection is being sold abroad. It is believed, however, that the American type of the Baird receiver may be simply a Nipkow disc, a slotted disc, and the collection of cells, together with the neon lamp. This was illustrated in the July RADIO BROADCAST in the article "What Hope for Real Television?" (p. 125)

So far as reception itself is concerned, any receiver with sufficient amplification and a power output can be used. Actually, the audio amplifier should preferably be changed to straight resistance coupling until transformers are available which do not have a distinct cut-off of frequencies above 5000 cycles.

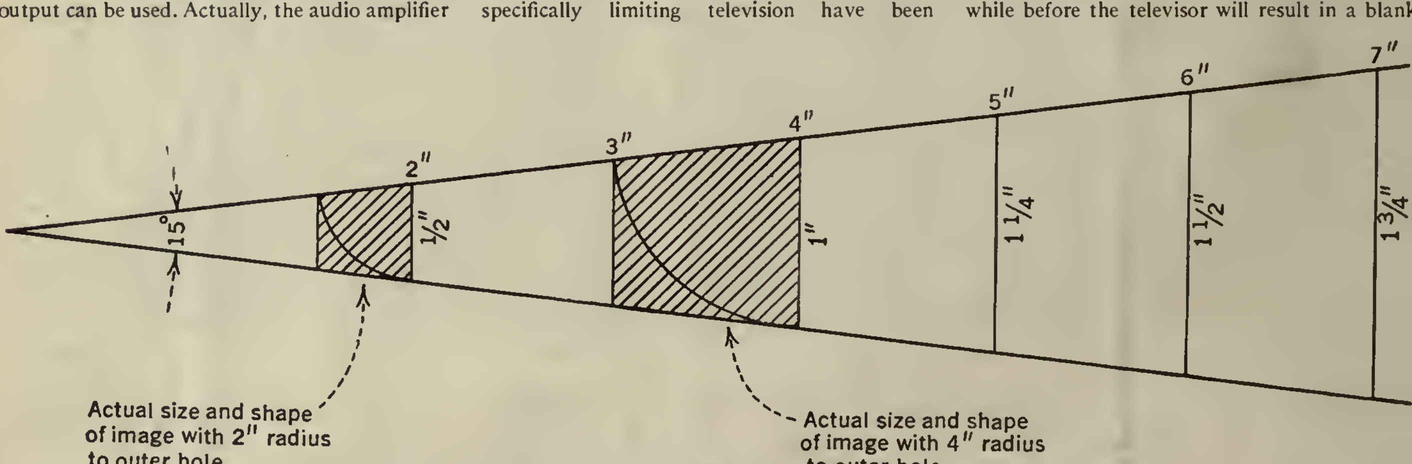
For the present, however, there is a legal limit of plus and minus 5000 cycles for the width of sidebands and this limit will not be exceeded. While the WGY figures give a possibility of 12,096 impulses per second, basing the modulation of each line as equal to the number of lines, actually the simplicity of the picture and quantity of white space in the background cuts down the line modulation. Likewise, Nakken's intention to send 36 lines and 10 pictures per second would run into 12,960 impulses per second if each line had 36 modulations. Here, too, the simplicity of the figures and the abundance of white background will act to bring the actual picture within the legal 5000 impulses per second.

It is not meant to imply that any regulations specifically limiting television have been adopted, so far as known. The fact remains, however, that the legal sideband possible without interfering with the next station is 5000 impulses, and it makes no difference, so far as interference is concerned, whether these impulses arise from sound variations at the studio or light variations which are transformed into electric impulses. It is true that WGY was given almost *carte blanche* on the occasion of one demonstration to the press. Various editors and writers still tell how much better that demonstration was than anything else they have seen, apparently not realizing that the use of 20,000 or more impulses to the pictures naturally would be infinitely superior in results to any picture, regardless of how it was sent, that uses 5000 impulses or less. The difference would be much greater than that between a newsprint half-tone of poor quality and the fine prints made for framing. The legal limitation must be overcome by some new method of transmission before even the crude possibilities of present television devices can be realized.

The contrast of the picture will depend upon the relative light intensities of the neon plate under slight voltage fluctuations or on the extent that those fluctuations are varied. The brilliancy of the image will depend largely on the size of the holes in the disc and the speed of the disc. High speed and small holes will make an image hard to see.

WHAT WILL THE FAN SEE?

THIS brings us, of course, to a consideration of what is to be sent and what you can see through these whirling discs. There is much talk of sending the pictures of performers so that you can see them and hear them, too. There may be an occasional attempt at this. Only the head will be sent, and no groups, such as orchestras, will be included. A single head can be put across, but it will be hardly recognizable except for the outline. You will know it is a head and distinguish between a man or woman. With proper make-up on the face, which art may be developed especially for a televisor, possibly a distinctive type of face and head can be recognized. A sneeze on the part of the artist, and the face will disappear. I am also inclined to believe that any attempt at singing by the artist while before the televisor will result in a blank



THE ACTUAL SIZE OF PICTURE POSSIBLE

This shows how the size of the scanning disc determines the size of the received picture. When the size of the disc is such that the radius from the center to the outer hole is two inches then the received image has a size and shape as indicated in the left hand shaded portion in this diagram. If the disc has a radius of four inches to the outermost hole then the size of the picture is as indicated in the shaded portion at the right. In both cases, however, the total number of scanning lines is the same and therefore with the four-inch radius the number of lines per inch is only half as many as with a two-inch radius. Consequently the larger the radius the less apparent detail there is to the picture.

RADIO ROW SEES A NEW BOOM

Down in New York's Radio Row, the crowds are thronging in the old 1923 fashion. The reason is apparent in the arrow-shaped sign at the top of this picture

screen, judging from the fact that in a demonstration a slight yawn on the part of one subject caused his face to drop off the screen.

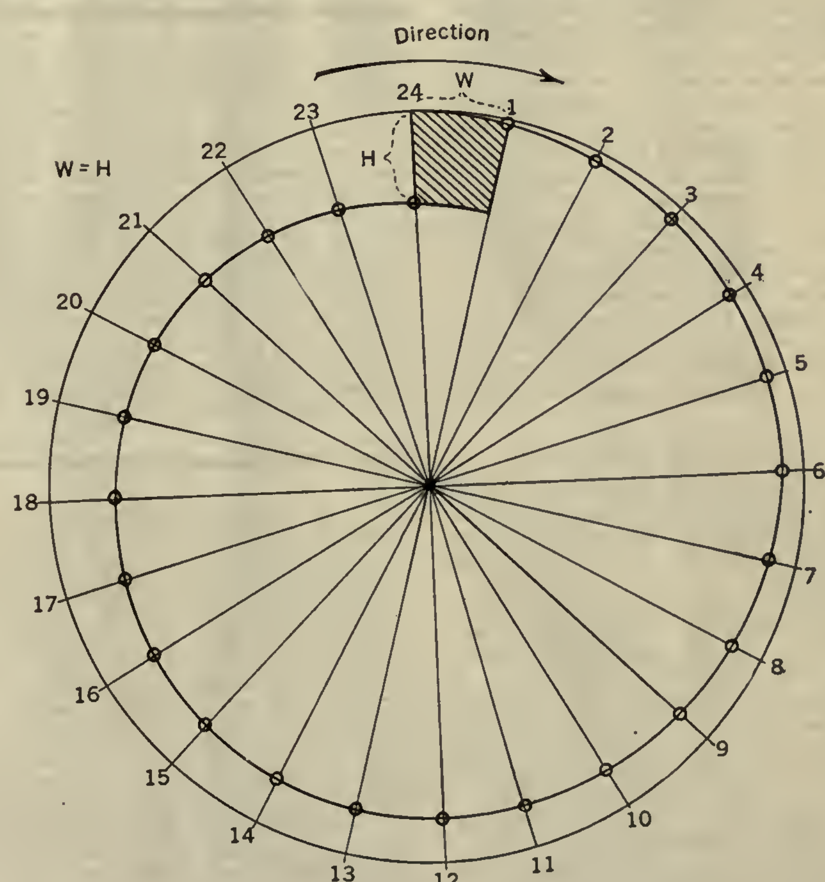
Actually, no proponent of the new art seriously contemplates this type of broadcast. Every one of them has in mind transmitting, not from living images, but from photographically recorded cartoons, using outline figures and silhouettes of the type shown in the comic strips. With these some degree of motion can be seen and the figures themselves can be so different in outline, as in the case of Mutt and Jeff, that the observer will be able to follow the action. You can tell whether little Jeff is leaning disconsolately against a lamp post or sitting at a table taking refreshment, but it will not be possible to distinguish whether Mrs. Mutt hits her distinguished husband with a rolling pin or a frying pan. You will be able to see the hit but not the sparks nor the lump that grows on the bruised spot.

Knowing what is being sent, how it is being sent, to what degree it will be received under the best conditions, and how to receive it, still leaves a good deal to be said. Nobody at this moment knows how satisfactory home built apparatus is going to prove, or how the broadcasts are going to go over in the face of possible static and other interference from internal and external sources. We do know that even mechanical vibration of the receiver makes the screen blank. In that particular, we recall the old cat's-whisker-and-crystal days when every member of the household had to sit rigid and hold his breath at the moment of an announcement. The rumble of a truck or the passing of a trolley might upset the sensitivity. All this is true of such home-built apparatus as has come to our attention. It may be equally true of commercially built receivers.

The problem of synchronization is not solved in any commercial type of apparatus yet disclosed. The best that any manufacturer contemplates is manual speed control of the motor. This is a hand operated rheostat, and it needs but little imagination to see that it is very difficult to hold the image in this way for more than a fleeting glance now and then, especially if the line voltage variation or fluctuation is very frequent. I am inclined to think much better results could be obtained with a six-volt motor on a storage battery. Any fan could do that, of course, as the particular source of the energy which turns the disc is of no importance. Even a spring motor would work if the speed were great enough, the power sufficient, and the period of operation long enough. I am informed that at least one manufacturer plans a device fixed automatically for only one speed, being even more accurately governed than a phonograph. Any variation in speed is detected by observing a second neon lamp through an auxiliary spiral of holes in the scanning disc.

Personally, I have confidence only in the establishment of a synchronizing station, perhaps one of the smaller ones forced from the broadcast field under the new law. For the television camera described by me last month, such a station sending constantly a 10-cycle sideband or a 1000-cycle sideband, or both, would not only take up little room in the spectrum, but furnish synchronizing means to transmitter and receiver alike. Such a station might well be subsidized by the larger ones and, moreover, would tend toward standardizing the speed of all receivers and prevent the growth of a multitude of separate forms of transmission which ultimately must be brought together. Sooner or later the purchaser will demand that his receiver be such that he can get any image broadcast. Imagine any radio receiver manufacturer trying to merchandise nationally a radio set which would receive only one station or one fixed wavelength! Yet that is just what the televisor producer plans to-day.

The cost of the commercial television attachment for a radio receiver will run to about $150. That means home-built apparatus for most fans. He can buy a first quality neon tube for $12.50, with the promise that this will go down to about $7.50 as soon as there is a demand that warrants a quantity production. The motor will cost from $9 upwards. It need not be over $\frac{1}{8}$-horsepower and, if belted to the disc, even a smaller motor may be suitable. The big difficulty will be in getting a suitable disc, unless manufacturers wake up to the fact that this piece of the apparatus must be of a high degree of accuracy. The cost of a suitable aluminum plate with the spiral holes cleaned out and countersunk will be quite high but well worth while in comparison with the paper discs now making their appearance in conjunction with a little neon night lamp now being widely sold for television purposes—for which it is worthless. This little bulb is good, however, to indicate whether you have a.c. or d.c. current, as it glows on both plates only with a.c.



A SCANNING DISC LAYOUT FOR WGY RECEPTION

The number of holes in the disc is determined by the constants of the apparatus at the transmitting end—24 holes is the correct number to receive the pictures beings transmitted by WGY. *W is the width of the picture and H is the height of the picture as it appears to the observer, the shaded portion therefore representing the actual size of the picture received with a disc of the above dimensions.*

All About Loud Speakers

By Joseph Morgan

THERE is no part of a broadcasting system, beginning with the studio and ending with the listener, which does not add its quota of distortion to the original performance which takes place in the broadcasting studio. Since the loud speaker is the last link in the chain of technical apparatus used in the system and the device which finally emits the reproduction of the original performance, it is natural, in fact almost traditional, to render judgment against the loud speaker for the accumulated deficiencies of the entire system, including the listener.

While it is true that the loud speaker has been a gross offender in the past, and until recently the weakest link in the chain, there are many possible imperfections of the system which are in no way chargeable to this much maligned device.

THIS article comes as a very timely comment on the present sweeping interest in loud speakers. The recent Trade Show at Chicago proved that the field of loud speaker development is at present the most active branch of radio. Mr. Morgan covers the whole field in a clear and concise manner, summing up the theoretical requirements of the ideal loud speaker, the various kinds of units that have been devised to meet these requirements and the results that may be expected from the present day types of loud speakers. Although the specific makes of units on the market to-day are not mentioned by name, the data in the text and the accompanying response curves should enable the reader to decide upon the type of loud speaker that will give him the kind of service he desires. In addition, Mr. Morgan gives some valuable hints on the proper way to make a non-technical comparison of loud speakers.

—THE EDITOR.

THE NATURE OF MUSIC AND SPEECH

ALTHOUGH much has been written concerning the physical nature of speech and music, a brief review may not be out of place here, since it is fundamental to any study of loud speakers.

Sounds are more or less regular vibrations in material media. The most important of these media is air. The most important properties of sound are pitch, intensity, and timbre.

The pitch of the sound is determined by the number of vibrations per second of the sounding body. When we speak of a musical note being high or low, we are speaking of the pitch of that note.

The intensity of a sound we ordinarily refer to as the loudness of the sound.

The quality of the sound is called the timbre. For example, the violin and the trumpet have different qualities or different timbres.

All musical instruments emit certain vibrations which are called fundamentals. We can, for example, play middle C on the piano or violin, and the pitch of these tones will be, let us say, 256 vibrations per second. We are, however, enabled to distinguish the middle C's of the piano and the violin by what are called "overtones." These overtones are, in general, exact multiples of the fundamental pitch. For example, a certain instrument may have a fundamental (middle C in this instance) of 256 vibrations per second, with overtones of 512, 1024, 2048, and 4096; while in another instrument the overtones of 1024 and 4096 may be practically or entirely missing. Therefore, the middle C would sound quite different when played on the two instruments. In other words the overtones which are present in a tone, and their relative intensities with respect to the fundamental, determine the timbre of that tone.

The piano, for example, has 88 notes or fundamentals. Each fundamental is associated with its own group of overtones, and this particular grouping of tones gives the piano its characteristic quality.

In the reproduction of speech and music it is therefore essential to reproduce all of the fundamentals and overtones in their original proportions. None may be omitted, none may be added, without causing distortion. Gross failure to observe these facts results in music which is unnatural and in which the various instruments are indistinguishable, and in speech which is unnatural and unintelligible.

FUNCTION OF THE IDEAL LOUD SPEAKER

WHAT constitutes the ideal loud speaker from the point of view solely of tone quality? Assuming the broadcasting, the transmission of the radio waves through space, and the remainder of the receiving apparatus to be ideal, should the loud speaker reproduction be an exact replica of the original performance in the studio? The answer to this question is not so simple as one might, at first glance, suppose. In this apparently simple question there are involved physical, psychological, and physiological factors. It is not possible in this article to analyze the many factors involved, even aside from the fact that the relative importance of some of these factors is not yet known. A few illustrative points, however, may not be out of place.

Amongst the important physical factors to be considered is the relationship which exists between the broadcast performance studio and the broadcast listener's room. The voice of a speaker delivering an address to an audience in a large auditorium will sound anything but natural if accurately reproduced in a very small living room. An orchestra, playing in a hall which has good acoustics, will sound most unnatural if accurately reproduced in a small resonant room; one, for example, with bare floors and walls, and containing very little furniture. It is very probable that a loud speaker could be constructed with certain intentional distortions which would give a better illusion of reality, in such a case, than a loud speaker causing no distortion.

As to the psychological factors, there are people who actually prefer certain types of faulty reproduction to the original, and there can be no question that a poor loud speaker may under certain conditions flatter a poor performer.

For example, a loud speaker whose response is poor at the higher audio frequencies will fail to reproduce much of the unpleasantness of a nasal voice or scratchy violin playing.

It requires little stretch of the imagination to believe it possible that distortions of various types may, in the future, be intentionally introduced into the system in order to produce new musical effects.

As an illustration of the physiological side of the problem let us consider the question of volume. It is a fact, unfortunately not sufficiently well observed, that even accurate sound reproduction will produce serious distortion in the ears of the listener if the volume of the reproduction is too great. This distortion is an "overloading" of the ear of a similar nature to the overloading of a vacuum tube.

We see from this brief discussion that the system does not end with the loud speaker, but with the listener; and further, that the problems which arise after the loud speaker has completed its task are not by any means unimportant.

For the purposes of the following discussion, however, we shall assume that it is desirable for the loud speaker to produce an exact replica of the original performance, and leave the special considerations of the listener, and the listener's room, for a later time.

THEORETICAL REQUIREMENTS

BASED on this simplified view of the problem, what should an ideal loud speaker do, if used in an ideal system?

Theoretically such a loud speaker should reproduce *all* the frequencies from 8 cycles per second to 12,000 cycles per second—nearly eleven musical octaves—without omission of any frequencies, and it should reproduce this entire band of frequencies without discrimination; in other words, without frequency distortion. It should not produce any frequencies not present in the original sound; in other words, it should not introduce non-linear distortion. It should be capable of delivering its output at sufficient volume without the introduction of distortion due to overload or mechanical striking of any of its parts. It should be efficient; that is, the ratio of the sound output power to the electrical input power should approach as nearly as possible to unity. Its performance should be independent of ordinary atmospheric conditions. It should be rugged and durable. It should be either inconspicuous or decorative—or both.

Needless to say, an instrument possessing all of the desirable qualities stipulated above cannot be found this side of paradise. Fortunately, however, we may fall short of this perfection and still obtain excellent results.

We shall examine in detail each of the above qualifications to see how much variation is consistent with a practical loud speaker, and we shall then compare these practical considerations with the actual limitations of present-day loud speakers.

First, let us consider the item of frequency range. It has been demonstrated that a frequency range of 30 cycles per second to 10,000 cycles per second is consistent with practically perfect reproduction of both speech and music. In fact, a system which reproduces 30 to 6000 cycles is distinguishable only by direct comparison from one which reproduces the entire range.

As to amplitude, it has been determined that a variation throughout the frequency range of less than 5 TU is almost negligible, and of more than 15 TU is serious.

As to non-linear distortion, it has been estimated that the presence of frequencies in excess of 5 per cent. (based on the energy of the original sound) is disturbing.

The efficiencies of most loud speakers are low, a value of one half of one per cent. being average. In other words, the power tube of the last audio stage delivers 200 units of electrical power to the loud speaker for each unit of sound power delivered by the loud speaker to the air. Of loud speakers built for home use, there are few which have an efficiency of as much as 2 per cent. The losses occuring in loud speakers are: (1) The heat losses in the coils; (2) The hysteresis and eddy-current losses in the magnetic circuit; (3) The work done in bending the diaphragm; (4) Losses due to air friction which do not contribute to the production of sound waves. If it were not for the very low efficiencies due to these losses it would not be necessary to use large power tubes in the last audio stage, to deliver the necessary power without overloading this stage.

An example may make this more clear. Suppose that a given good speaker, having an average efficiency of $\frac{1}{2}$ per cent. is used in an average living room, and that it is necessary to use a type 210 tube in the last stage of a two-stage audio amplifier to obtain reasonable volume without appreciable distortion. If this same reproducer had an efficiency of 50 per cent., the same volume could be obtained with no increase in distortion by using a type 199 tube in the last stage. In other words the smallest of the standard dry-cell tubes operating with a plate voltage of only 90 volts would be quite as effective as the high-voltage power tube.

The desirability of increased efficiency is obvious, since a large part of the complication and cost of a good modern receiver is brought about by the necessity of using power tubes. Power tubes are more expensive and require, in general, high plate voltages and high plate currents. This in turn means power supply devices with expensive transformers, rectifiers, and filters. It is safe to say that a large proportion of the total cost of a good broadcast receiver is chargeable to the low efficiency of the usual loud speaker.

PRINCIPLES OF DESIGN

TELEPHONE receivers and loud speakers have been designed upon a number of basically different principles. The electrostatic attraction between two charged metal plates; the reaction between the current in a coil and eddy-currents set up in a large metal disc; the expansion and contraction of crystals under the influence of an alternating electric field; the expansion and contraction due to the generation of a gas from a chemical placed between two plates, resulting from the passage of the audio-frequency current through the chemical; the variation of the surface tension of a liquid with electromotive force; thermal expansion and contraction of a wire with variation in current through the wire; the "talking" arc—all these and many other schemes have been used with more or less success.

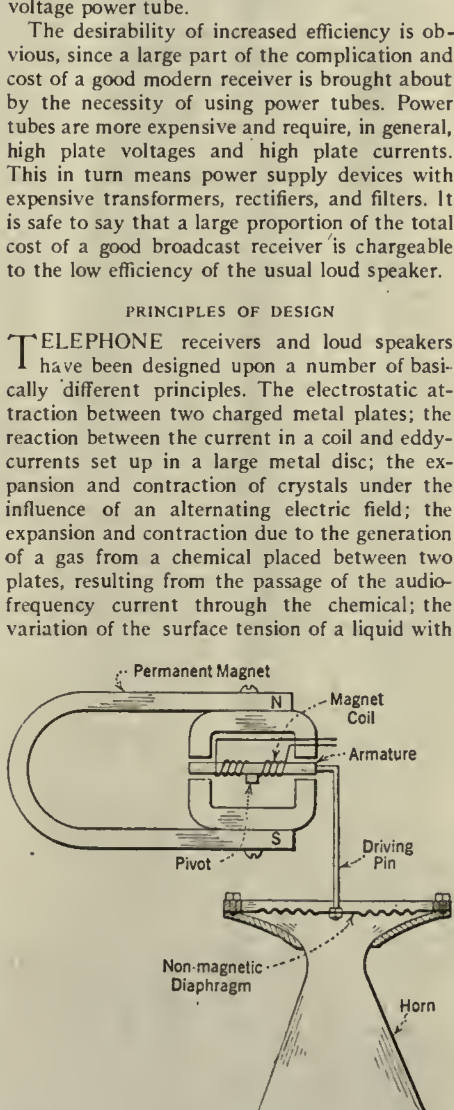


FIG. 2. HOW THE BALANCED ARMATURE LOUD SPEAKER IS CONSTRUCTED

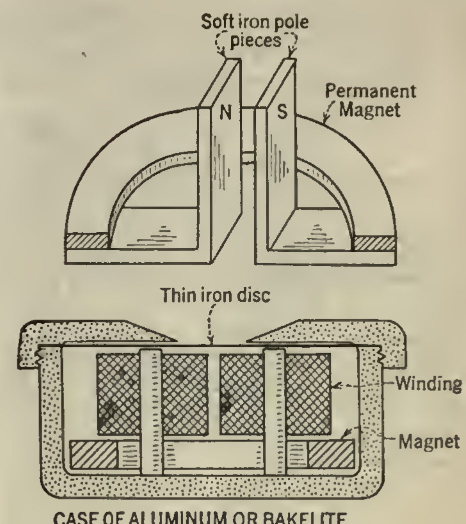


FIG. 1. CONSTRUCTION OF THE IRON DIAPHRAGM TYPE OF LOUD SPEAKER UNIT

However, practically all speakers in use today depend upon the variation in pull of a fixed magnet or electromagnet on an iron diaphragm, iron bar (armature), or a coil carrying current. The essential parts of a speaker working on this principle, no matter of what type, is a constant magnetic field upon which is superimposed a second magnetic field which varies in accordance with the audio-frequency current, thereby causing the motion of a diaphragm, an armature, or a moving coil in accordance with audio-frequency current.

CLASSIFICATION OF LOUD SPEAKERS

THE reproducers obtainable at present may be divided into several classes.

The first classification refers to the method of exciting the constant field. Those which use a permanent magnet are called magnetic. Those in which the field is excited by means of a current-carrying coil wound on a soft iron core are called electromagnetic.

A second classification divides speakers into iron diaphragm, balanced armature, and moving coil types.

The iron diaphragm unit has the same general construction as an ordinary watch-case telephone receiver. In this type the iron diaphragm is magnetically attracted to the pole pieces of the magnet, against its own spring tension. The diaphragm is the emitter of sound. Fig. 1 illustrates the construction of this type.

The balanced armature type consists of a short iron bar or armature which acts as the core of a small coil carrying the audio-frequency current. This bar is pivoted at its center and is free to move in a small arc about its center. It is usually restrained by a light spring. Each end of the bar is near one of the pole pieces of a strong permanent horse-shoe magnet. This bar imparts its motion to a non-magnetic diaphragm (to be discussed later) through a simple rod or in some cases through a more or less complicated system of levers. Fig. 2 shows the construction.

In the moving-coil type a very small, exceedingly light cylindrical coil, carrying the voice and music current, moves back and forth in the magnetic field. In this case the coil is attached (usually directly) to a non-magnetic diaphragm. See Fig. 3.

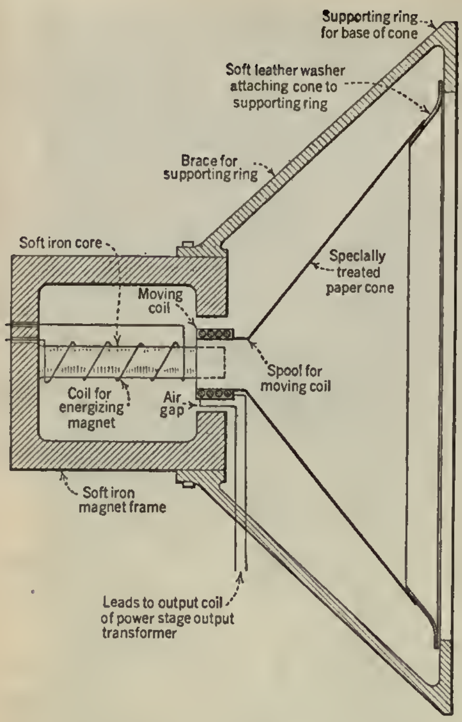


FIG. 3. CONSTRUCTION OF THE MOVING COIL TYPE OF LOUD SPEAKER

The third classification consists of "horn" and "hornless" speakers. This classification is self-explanatory. The function of the horn is to load the diaphragm and to radiate the power which it causes the diaphragm to deliver. The greater the loading, the less the objectionable effect of diaphragm resonances. The loading of an exponential horn increases with decrease in the initial throat area. However, the throat area must not be so small as to introduce appreciable air friction. The less the rate of increase of the cross-sectional area of the horn, the more uniform the loading will be. The larger the final opening, the less pronounced will be the horn resonances. Therefore, a good exponential horn should have a small initial throat area, a slow rate of taper and a large final opening.

With a very few specific exceptions, all loud speakers fall within the above system of classification.

While it is evident that there are many possible combinations of the above-mentioned elements, there are at the present time five principal types which will be described as representative of most of the speakers on the market.

The commonest or ordinary "horn speaker" is the combination of the permanent magnet, iron diaphragm, watch-case telephone receiver unit, with a more or less conical horn, usually about two feet in length. The characteristic of a good speaker of this type is shown in Fig. 4. This type of speaker has almost every inherent fault possible. The permanent magnet is usually so small

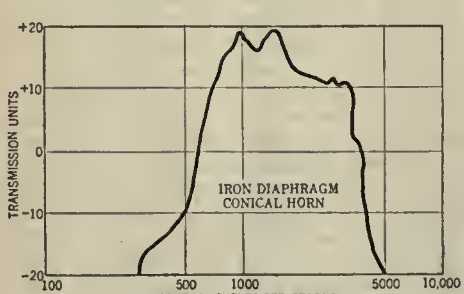


FIG. 4

that non-linear distortion is certain to be present if the speaker produces reasonable volume. Due to the fact that the diaphragm is essentially a spring and therefore has a natural period or frequency of its own, frequency distortion is present in a high degree. Furthermore the conical horn discriminates against the lower frequencies. See Fig. 7. The only advantage which can be claimed for this type of speaker is that it tends to cover up the distortion due to overloaded tubes, since it cannot reproduce the high audio frequencies.

The second or "exponential horn" type of speaker employs a large watch-case telephone receiver unit with an exponential horn. If properly designed, this speaker is decidedly superior, particularly since a correctly proportioned exponential horn will radiate a wide band of frequencies with good uniformity.

The combination of a permanent magnet, balanced armature, small non-magnetic diaphragm (usually mica or aluminum) with an exponential horn can give a still better frequency-response curve and can also be more efficient. The frequency-response curve of an example of this type of speaker is shown in Fig. 8.

A fourth and very common speaker called the cone speaker employs a permanent magnet and a balanced armature which is connected by a rod or lever system to the apex of a large conical diaphragm, commonly made of specially prepared paper, which resists changes in shape or stiffness due to heat or moisture. In the most usual type, the base of this conical diaphragm is fastened to the base of a second conical diaphragm at the common periphery. This is a type of "fixed-edge" cone. The diameter of the cone varies from one foot to three feet, eighteen inches being a very common size. If well designed this type of speaker has a good frequency-response curve. Such a curve for a fixed-edge cone speaker of well-known make is shown in Fig. 5. It will be noticed that there are a number of peaks in this curve, partly due to the fact that the cone does not vibrate as a whole, and therefore has several modes of vibration resulting in numerous resonances.

Speakers of this type in the smaller sizes have the advantage of compactness, but they must be handled with care since the cone is usually quite fragile. In most speakers of this type an adjusting pin is provided to compensate the small alterations in the tension of the paper cone due to atmospheric changes.

The impedance of a well-known example of this type of speaker is 1000 ohms at 100 cycles per second and 40,000 ohms at 5000 cycles per second, and is chiefly reactive. This variation in impedance is characteristic of all types of loud speakers so far considered. The ideal speaker would have a constant impedance at all audio frequencies. It is further desirable that this impedance should be as nearly pure resistance as possible.

The fifth type of speaker to be described is the dynamic speaker. It has a strong constant field which is excited usually either by a 6-volt storage battery ($\frac{1}{2}$ ampere), or by 90 volts d.c. (40 milliamperes). The field consumes approximately 3 watts. In the low-voltage type the field can be excited from the usual A battery. A common method of exciting the field of the high-voltage type is to use this field as one of choke coils in the filter system of the B-supply device. This second way is of course more efficient. A recent model utilizes rectified 110-volt a.c. to excite the field. In this model the field consumes 25 watts. This permits the use of larger air-gaps, and hence more rugged construction. The magnetic field in the air-gap is radial. The moving coil, which consists of about 150 turns of very fine wire wound on a thin cylindrical shell of fibre or like material, has a very low impedance at all audio frequencies. In one well-known make this impedance is about 5 ohms at 100 cycles and 10 ohms at 6000 cycles. Its impedance is almost pure resistance and therefore is nearly constant throughout the audio-frequency range. This is a distinct advantage, since it is desired to have the speaker respond alike to all frequencies. The coil has the smallest practicable clearance in the air-gap. A cone, usually made of paper, is attached rigidly at its apex to the moving coil. The base of the cone is fastened loosely by some soft and flexible material, such as thin leather, to an outside supporting ring such as is shown in Fig. 3. Two, or sometimes three, thin flat metal springs keep the moving coil concentric in the air-gap and act as conductors of current to the coil.

It may be seen from this description that the cone is almost full floating. The lightest touch of the finger will displace the cone in some cases as much as a quarter of an inch along its conical axis. Such a cone is said to have a "free-edge." The resonant frequency of the cone, coil and spring combination is made very low, usually less than 50 cycles per second, so that the speaker is practically a non-resonant pure resistance load on the amplifier, for most of the audio-frequency range.

In order to utilize this type of speaker to the best advantage it is necessary to mount it in some kind of cabinet or stiff baffle board. Since the cone moves as a whole, the waves from the front and from the back tend to interfere, particularly at the lower frequencies (under 300 cycles per second), unless the shortest path from front to back of the speaker is of the order of magnitude of the length of the low frequency waves. The distance from the *front* edge of the cone to the back edge by the shortest mechanical path through the air around the cabinet or baffle should be at least one quarter wavelength of the lowest note to be reproduced, 32 inches for 100 cycles, 110 inches for 30 cycles. It might be thought that if the speaker were completely enclosed in a small box that this problem would be solved. However, such is not the case, since disturbing resonances will be produced. Therefore, the speaker should either be mounted in a console cabinet, or, better still, in a large wall.

Such a speaker properly mounted and used with a good amplifier is capable of excellent results. The frequency-response curve for a speaker of this type is shown in Fig. 6. It will be noted that the solid curve shows a peak for the band of frequencies from 2000 cycles per second to 5000 cycles per second. This is due in part to the horn effect of the small cone at the higher frequencies and in part to vibration of the cone. In a recent model, a ribbed cone is used which is claimed to minimize this vibration. Some dynamic speakers contain equalizer-filters which tend to correct this defect, as shown in the dotted curve in Fig. 6.

Since the impedance of the moving coil of the usual dynamic speaker is exceedingly low in com-

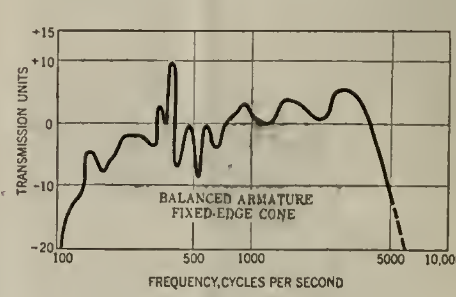


FIG. 5

parison with the output resistance of standard radio tubes, it is necessary to use a transformer designed particularly to bring these impedances into the proper relationship. In some speakers this transformer is included in the housing of the speaker. Separate transformers are now available, which have been designed to be used between the moving coils and the standard power tubes. When purchasing one of these transformers, the particular power tube, or tubes (if the last audio stage is push-pull) used in the set must be specified, as different transformation ratios are desirable for different tubes. Most of these transformers are so designed that the impedance looking from the tube into the primary of the transformer is twice the plate resistance of the tube. This condition gives maximum *undistorted* output. In the dynamic speaker, if this relationship is made right for a frequency of about 1000 cycles per second, it is approximately right for the entire audio range.

It is very important to mention that while some types of speakers are theoretically inherently better than others, in practice, due to inadequate design, this is frequently not so. The writer has seen more than one make of cone speaker which was inferior in almost every way to the average conical horn speaker. A dynamic speaker recently came to the attention of the writer which was one of the poorest speakers he had ever examined. The type of unit determines its *theoretical* excellence, but careful design makes a good loud speaker.

REQUISITES FOR A BROADCAST RECEIVER

THE question of judging the quality of a loud speaker is, properly considered, a laboratory study. However, the *relative* merits of different speakers can be determined with a fair degree of practical accuracy if they are *intelligently* compared while listening to a good local broadcasting station through an adequate receiving set.

Before describing the method of comparison it will be well to discuss in general terms the requisites for a good broadcast receiver from the point of view of audio quality. In the first place the set must not be more selective than is absolutely essential for the separation of stations. As a rough measure of this, the set should *not* be capable of separating two stations of equal strength and distance, separated by 20 kc. in wavelength. Selectivity, in general, is incompatible with quality, since the more selective a set is the more it sacrifices the higher audio frequencies.

An overloaded detector is a frequent cause of distortion. There is no need to overload the detector provided the audio amplifier has sufficient gain. Such an amplifier should have a gain of at least 60 TU and preferably 70 TU. With such an amplifier sufficient volume is obtainable from the loud speaker with a small detector output and without the use of regeneration in the detector circuit.

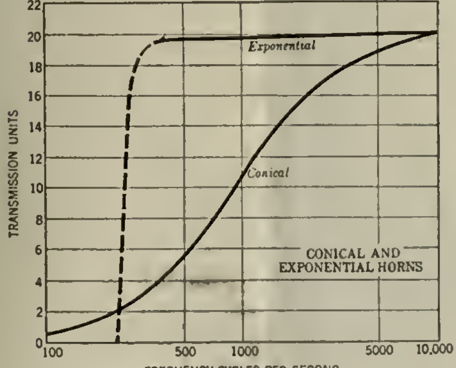


FIG. 7

These curves were made for the natural response of a cone or an exponential horn, without driving units

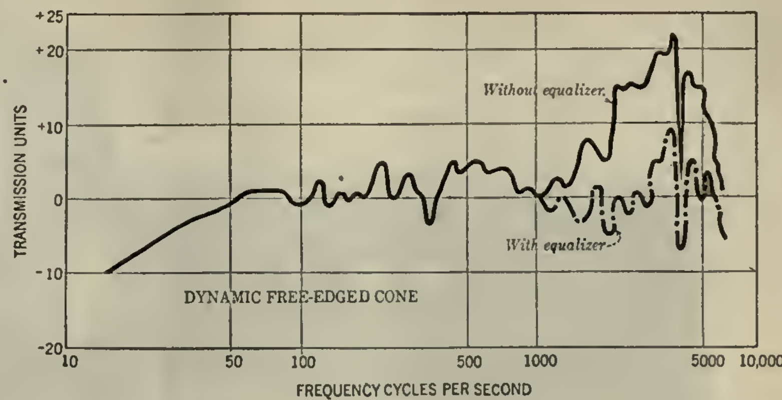


FIG. 6

The audio-frequency amplifier is a source of almost every known type of distortion. The modern transformer-coupled amplifiers using the best makes of transformer and connected according to the manufacturer's directions, paying particular attention to obtaining the correct A, B, and C voltages on all tubes, are capable of excellent performance. Unfortunately, there is no reliable way of testing such amplifiers without laboratory equipment of a type which is not generally available.

The design of the power stage of the audio-frequency amplifier is very important. It is safe to say, that in order to obtain, in an average room, reasonable volume without appreciable distortion it is necessary to have available at least one watt of undistorted output, if the loud speaker has a good frequency-response characteristic. This requires a last stage at least the equivalent of a type 210 tube. With the best types of speaker available at the present time it is desirable to use a push-pull circuit for the last stage, with type 171 or type 210 tubes. There is now available on the market a tube (type 250) with a still greater output. One of these tubes is sufficient to give a large undistorted output for a loud speaker used in quite a large room. Two such tubes used push-pull with proper associated apparatus will deliver sufficient power to fill a fairly large auditorium.

The method of coupling the speaker to the power stage is a matter of much importance. Two schemes are in common use; the transformer, and the choke coil and condenser. If the tube and loud speaker have the proper impedance relationship the choke and condenser scheme is efficient, but if the impedance relationship is not correct, a transformer should be used which has been designed for that particular combination of tube and speaker.

In any case the maximum undistorted power is delivered to the speaker when the impedance looking from the plate circuit of the tube into the primary of the coupling transformer is twice the plate resistance of the tube.

Loud speakers should never be compared by listening to their reproduction when connected to a poor receiving set, since the better of the speakers will sound worse. This is due to the fact that the better the frequency-response curve of the speaker the more the defects of the receiver (especially overloading), will appear in the reproduction.

If, however, two loud speakers are connected to a double-pole double-throw switch, the knife posts of which are connected to the output of a *good* set, which set is tuned to a *good local* broadcasting station, a useful comparison may be made. The relative intelligibility of speech is an indication of the presence of the higher audio frequencies. If "f," "s," "v," "b," "p" and "th" are *clearly* distinguishable, the loud speaker has a good high-frequency characteristic. If, when listening to the piano, the tones are deep and rich, the low-frequency characteristic is good; on the other hand, if the piano sounds thin and tinny the low-frequency characteristic of the speaker is deficient. If the voice is full and clear and intelligible, and yet has an unnatural metallic quality, there is at least one high peak in the middle or upper range of the frequency-response curve.

As shown by the curves in Figs. 4 to 8 inclusive, any or all of the above defects may be found in loud speakers. If, however, the comparisons are made intelligently, noting the above-mentioned points, a practical choice of speakers can be made on a rational basis, but the observer must assure himself that the defects noted are speaker defects and not defects arising from inferior broadcasting or an inadequate receiving set.

The development of the art and science of broadcasting has been very rapid, and remarkable results have been achieved in every branch. A large and reliable manufacturer announced only a few months ago the perfection of a loud speaker for use in public address and other commercial systems, which has an efficiency of 50 per cent. and a practically flat frequency-response curve from 20 to 8000 cycles, devoid of all sharp resonances!

It is likely that little time will elapse before such an instrument will be available to the broadcast listener.

Perfect radio reception is no longer a remote phantasy.

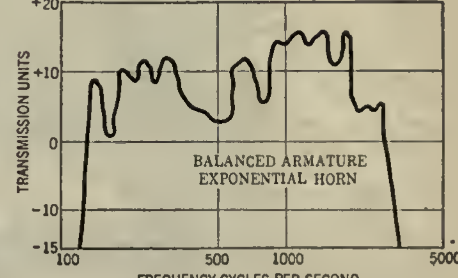


FIG. 8

THE RECEIVING ENSEMBLE

At the left is the receiver itself; at the right is the amplifier-power unit designed for use with the receiver, and the other receiving accessories

A Dual Control A. C. Receiver

By Robert Burnham

SOME interesting features have been incorporated in this dual-control receiver employing four stages of tuned radio-frequency amplification. The points of major interest are: Two of the radio-frequency transformers are arranged with adjustable primary windings so that the selectivity of the receiver may be adjusted to the conditions under which it is to be operated; an extra socket is placed in the receiver into which a phonograph pick-up may readily be placed; a combined power amplifier and B-supply unit has been constructed which is designed especially for use with the set and, although standard type CX-301A (UX-201A) *tubes are employed, the receiver may be made completely light socket-operated by using an A power unit in conjunction with this B-power unit.*

—THE EDITOR

THE problems associated with the construction of a radio receiver are many, and the final design is generally a compromise between various factors, such as the gain, type of tuning control, etc. The final design must be such as to produce an easily operated radio receiver with a reasonable amount of sensitivity and capable of giving good quality signals from any stations within a reasonable distance of the location in which the set is operated.

This has been the mode of approach in the design of the receiver described in this article. The complete receiver contains three tuned stages of radio-frequency amplification followed by a non-regenerative detector and a two-stage audio-frequency amplifier, transformer coupled. The first two tuning condensers are ganged to one tuning dial and the third and fourth tuning condensers are ganged to a second dial. These are the two major tuning controls. Two vernier condensers are connected across the second and fourth tuning condensers so that accurate tuning may be obtained when a comparatively weak signal is being received. In the reception of local stations it is necessary to adjust only the two main tuning controls and the volume control. The receiver is quite selective.

The only additional control on the panel is the filament rheostat, which is used in conjunction with the filament voltmeter to adjust the filament voltage applied to the tubes to the rated value of five volts. The 100-volt voltmeter on the panel is also useful in obtaining and checking the proper operation of the receiver, but it is not absolutely essential and may be omitted if the constructor so desires.

The receiver is shielded by means of the three aluminum shields. The first stage of audio-frequency amplification is located in the receiver proper and the second or power stage uses a 210 type tube and is a part of the combined power amplifier and B supply. A choke-condenser output circuit is used to keep the d.c. plate current of the 210 tube out of the loud speaker circuit. In the radio frequency, detector, and first audio sockets 210A type tubes are used and filament current for these tubes can be supplied from an A-power unit so that the entire installation is light socket operated. An additional socket is placed in the receiver so that a phonograph pick-up can be used.

THE CIRCUIT OF THE RECEIVER

A CAREFUL inspection of the circuit diagram in Fig. 4 will bring out some interesting points regarding the r.f. amplifier. In the first place, two of the r.f. transformers are arranged with primary windings whose coupling to the secondary may be readily varied. As the coupling is decreased, i.e., as the spacing between the primary and secondary is increased, the selectivity is increased; in this manner adjustments may be made to suit the conditions under which the receiver is to be operated.

A second point of interest about the r. f. ampli-

LISTS OF PARTS

FOR THE RECEIVER

L_1, L_2, L_5, L_6 — R. F. transformers, Hammarlund Type RF-17

L_3, L_4, L_7, L_8 — R. F. transformers, Hammarlund Type HQ-1

L_9—Hammarlund 85-millihenry r.f. choke
C_1, C_2, C_3—Carter 0.5-mfd. bypass condensers
C_4, C_5, C_6, C_7 — Karas 0.00037-mfd. variable condensers
C_8, C_9—Hammarlund midget condensers, Type MC-5
C_{10}—Muter 0.002-mfd. fixed condenser
C_{11}—Muter 0.0005-mfd. fixed condenser
C_{12}—Muter 0.00025-mfd. fixed condenser
C_{13}—X-L Variodenser, Type N
R_1, R_7—1,500-Ohm Yaxley grid resistors, Type 71500
R_2—1000-Ohm Yaxley grid resistor, Type 71000
R_4—Muter 6-ohm rheostat
R_5—Electrad 2000-ohm variable resistor, Type F
R_6—Muter $\frac{1}{4}$-ampere Tubestat
R_7—Muter 3-megohm grid leak
T_1—Karas audio transformer, Type 28
V_1—Filament voltmeter, 0–8 volts, Jewell Type 135
V_2—Plate voltmeter 0–100 volts, Jewell Type 135
3 Karas brackets
4 Alcoa shields
Front panel 7" x 24" x $\frac{3}{16}$"—Celoron
Sub-panel 10" x 23" x $\frac{3}{16}$"—Celoron
2 National illuminated vernier dials
1 Belden 7-wire fused cable
2 condenser shafts $\frac{1}{4}$ inch diameter, 10 inches long
Belden Colorubber hook-up wire
6 Benjamin base mounting sockets

FOR THE POWER UNIT

C_1, C_2, C_3, C_4, C_5—Muter power condenser blocks, No. 598
C_6—Muter 0.5-mfd. condenser, No. 507
C_7—Muter 2-mfd. power condenser, 600 Volt
T_1—Power transformer; L_1, L_2—Filter choke coils — Both contained in Thordarson Power Compact, Type R-210
T_2—Karas audio transformer, Type 28
L_3—Muter audio choke, No. 3130
R_1—1500-ohm Ward-Leonard resistor
R_2—150-Ohm Centralab variable power resistor
R_3—Heavy-duty high-range Clarostat
R_4, R_5—Muter 10,000-ohm resistors, Type 2910
8 Eby binding posts
2 Benjamin sockets
Hook-up wire

The following apparatus is also necessary to make the receiver operative:
5 CX-301A tubes
1 CX-310 power amplifier tube
1 CX-381 rectifier tube
Loud speaker such as the Magnavox Dynamic Cone
A-Power unit such as the Abox
Frost 100-foot antenna wire, with ground lead and clamp

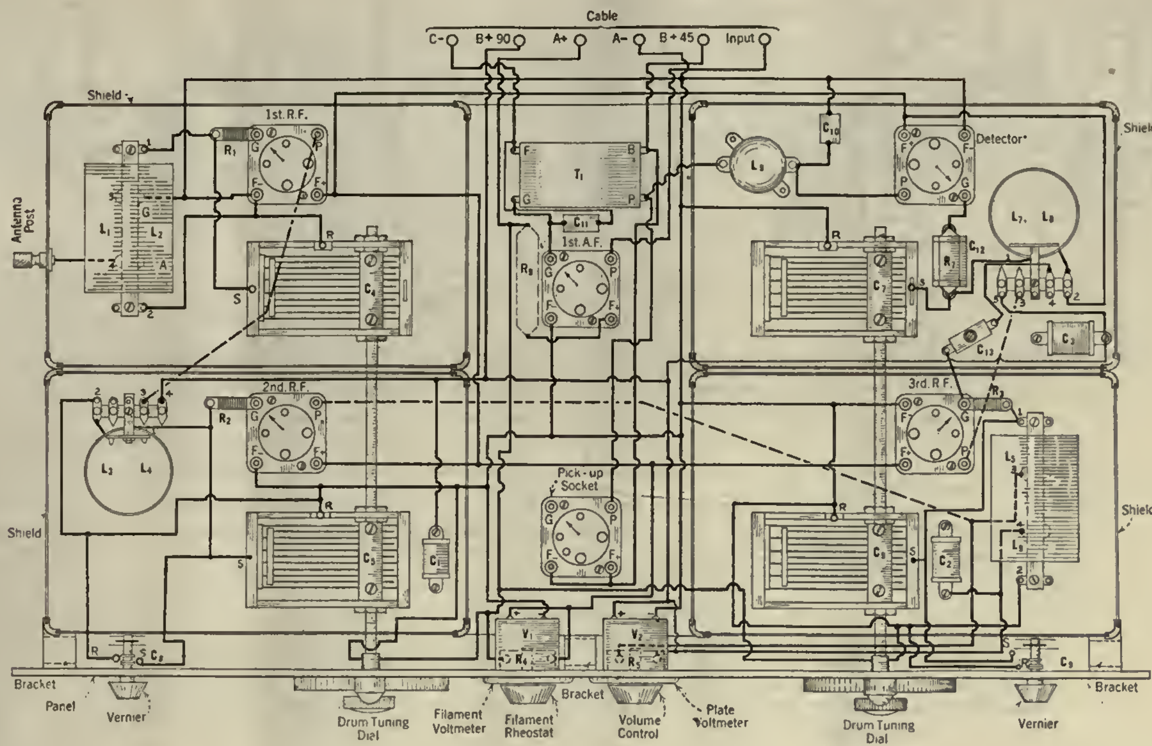


FIG. 1. THE PICTURE WIRING DIAGRAM OF THE RECEIVER

fier is that the various circuits have been stabilized by means of grid resistors. In the final stage a neutralizing condenser is also used. Without the neutralizing condenser in the circuit or with the condenser improperly adjusted the amplifier will oscillate over the entire band. With the neutralizing condenser correctly adjusted, however, the circuit is entirely stable.

The volume control is located in the r.f. amplifier and consists of a variable resistance across the primary of the third r.f. transformer. Care is necessary in the selection of the method of volume control. A filament rheostat on the r.f. tubes would not be very satisfactory because the output voltage of an A-power unit increases when the load is decreased, and therefore, if the volume is lowered by decreasing the filament voltage on the r.f. tubes the filament voltage across the other tubes in the set would rise above normal and shorten their life considerably. A resistance in series with the B-plus lead to the r.f. transformer is also unsatisfactory because it will cause wide variations in the voltages applied to the plates of the detector and first audio tubes. A variable resistance across the primary of an r.f. transformer has none of these disadvantages. It operates very smoothly and does not cause any changes in the plate or filament voltages applied to any of the tubes.

An r.f. choke is placed in the plate lead of the detector to keep r.f. currents out of the audio amplifier, and a small 0.002-mfd. fixed condenser bypasses the radio-frequency currents from the plate to the filament of the detector tube.

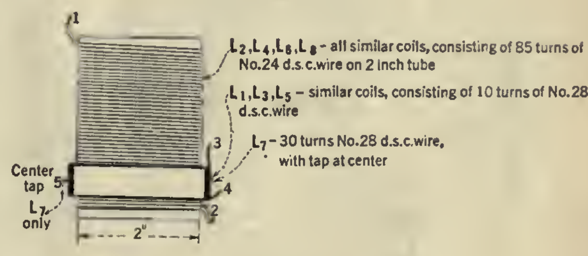


FIG. 2. THE COIL DATA

As was mentioned previously, an extra socket is placed in the receiver so that a phonograph pick-up may be used. The plate terminal of this

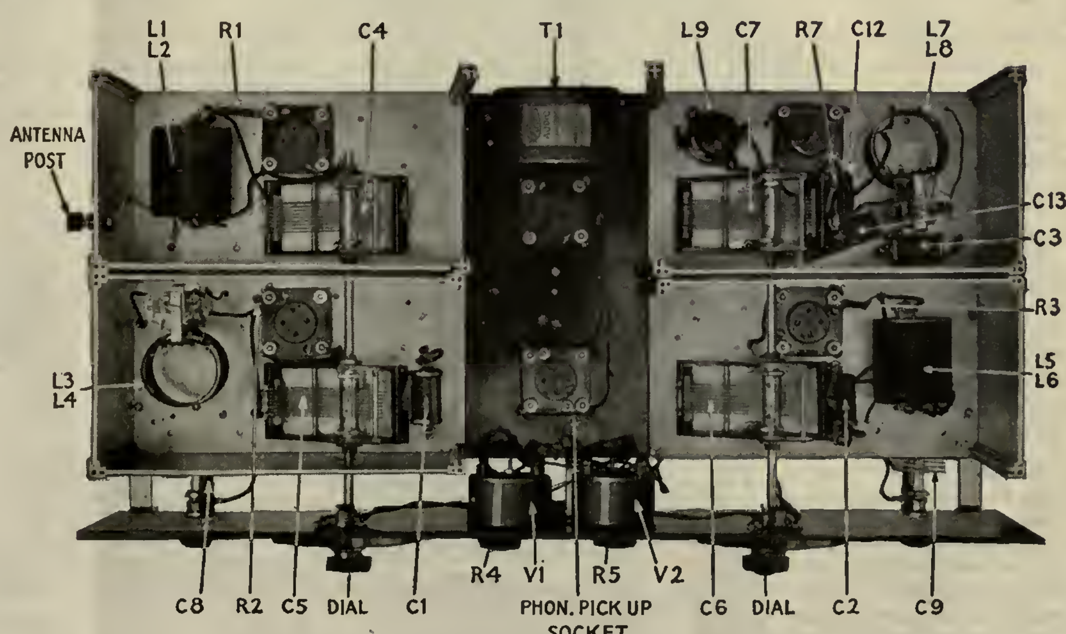


FIG. 3. THE RECEIVER FROM ABOVE

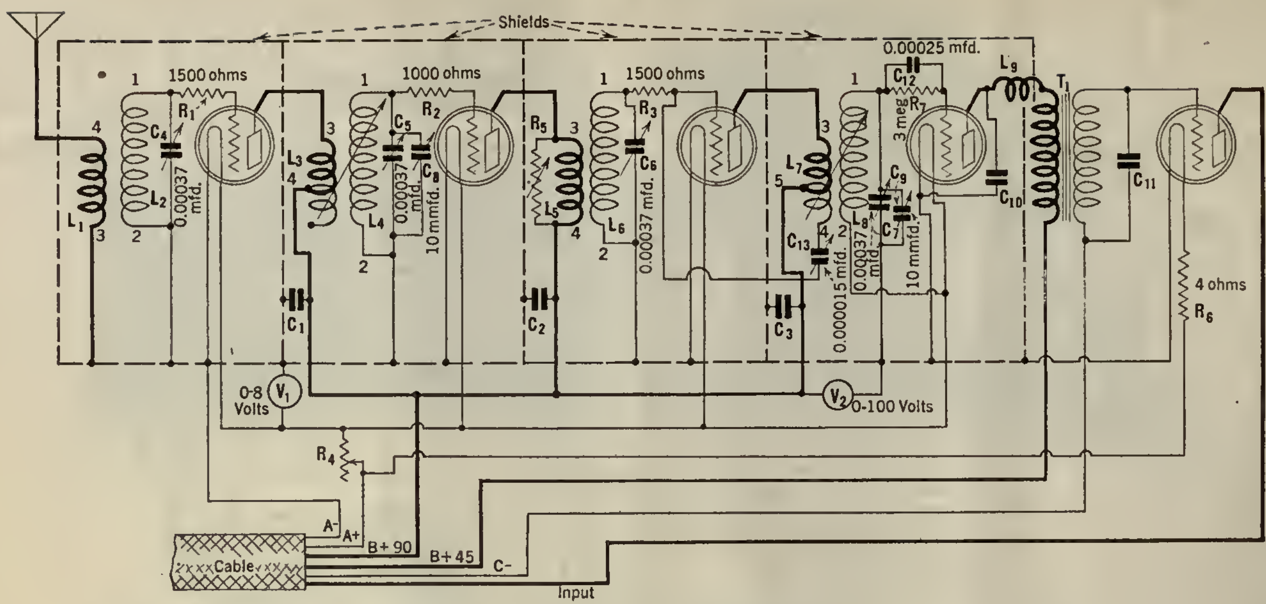


FIG. 4. THE CIRCUIT OF THE RECEIVER

The receiver described in this article consists, as shown by this circuit diagram, of four stages of tuned r.f. amplification, a grid-leak condenser type detector and a single stage of audio amplification, the second stage of amplification being incorporated in the power amplifier and B supply. For those that desire to use a phonograph pick-up it is suggested that an additional socket be included in the set. The placement and wiring of this additional socket is indicated in the picture diagram, Fig. 1.

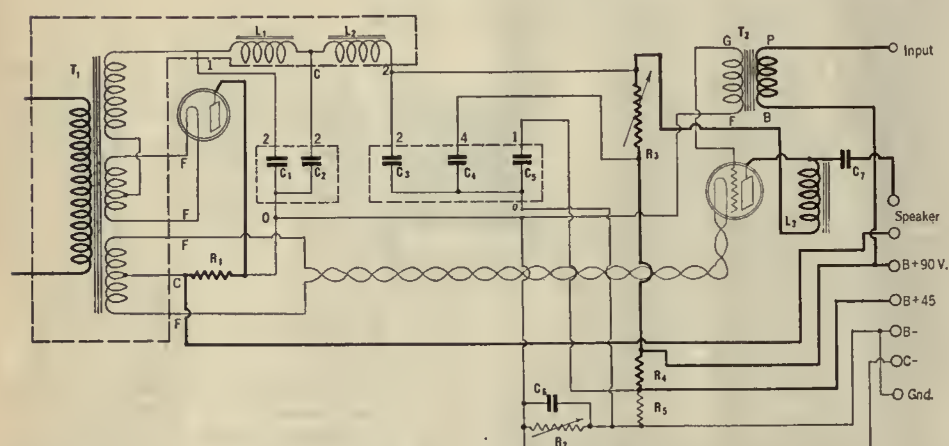


FIG. 5. THE CIRCUIT OF THE POWER UNIT

This power amplifier and B supply, designed for use especially with the receiver described in this article, supplies A, B, and C voltages to the type 210 power amplifier tube and B and C voltages for the receiver itself. This power unit, in conjunction with an A-power unit, such as the Abox, makes possible the operation of this receiver directly from the light socket

extra socket connects to the P terminal of the first stage audio transformer. The two filament terminals are wired together and are connected to the B plus terminal of the same transformer.

Therefore, when the adapter from a phonograph unit is plugged into this socket, the pick-up is connected directly across the transformer primary. When the pick-up is being used, the detector and radio-frequency amplifier tubes may be turned off. This is accomplished by tuning the filament rheostat on the panel to zero, in which position all the filaments except that of the first a.f. tube are turned off.

HOW TO ASSEMBLE THE RECEIVER

THE assembling of the receiver should not be very difficult if the circuit and picture diagrams are carefully followed. The circuit diagram of the receiver is given in Fig. 4 and the picture layout in Fig. 1. Specifications for home-made r.f. transformers are given in Fig. 2, the lettering on the coils corresponding to the same numbers in the circuit diagram. Fixed primaries are used in these home-constructed coils because they are more easily constructed than coils with adjustable primaries. A top view of the receiver is shown in Fig. 3.

If manufactured coils of the make specified in the list of parts are used, it is essential that the first and third coils (L_1 and L_2, and L_5 and L_6) be mounted by means of only one mounting screw at the primary end. If mounting screws are placed through the hole at the grid end, the coil will be short circuited by the shield. The bypass condensers, C_1, C_2 and C_3, should also be mounted with one screw.

The accurate alignment of all four tuning condensers is accomplished by loosening the clamping screws on the tuning condensers and then adjusting, by hand, the position of each rotor so that maximum volume is obtained.

The power unit illustrated in this article has been constructed especially for use with this receiver. It is a combination power amplifier and B supply. The circuit diagram is given in Fig. 5 and the picture layout in Fig. 6. In adjusting the complete installation, the power Clarostat in the power unit is adjusted so that the voltmeter, V_2, on the receiver panel reads 90 volts. The 150-ohm Centralab variable resistance supplies C bias to the first audio tube.

The parts used in the receiver and power unit illustrated in the article are given on page 192. Other equivalent parts may, of course, be used.

The set illustrated in this article was made for RADIO BROADCAST by the Rossiter, Tyler & McDonnell Service.

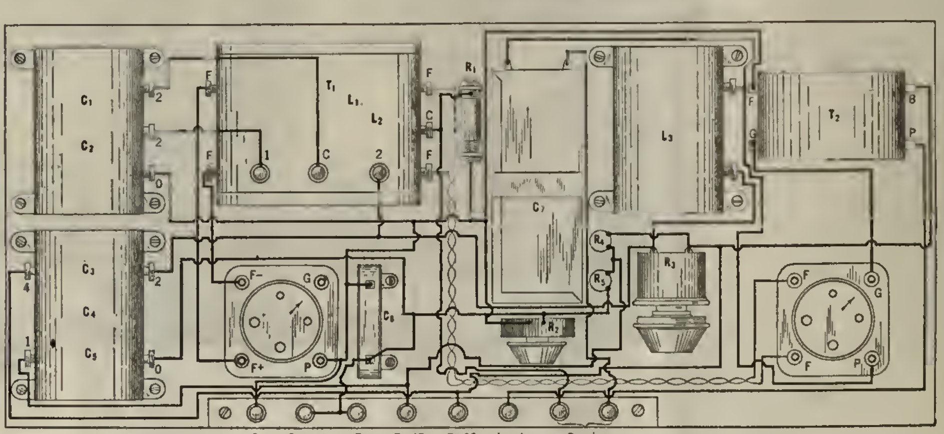


FIG. 6. THE PICTURE WIRING DIAGRAM OF THE POWER UNIT

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

The War on the Short Waves

WERE a modern Columbus to discover a New World, the nations of the earth would speedily sally forth to seize their share of its virgin lands. In the last decade, science has discovered such a new world in the ether and the nations are rushing feverishly to stake out claims by inaugurating new short-wave services.

Commissioner LaFount stated before the House Committee on Appropriations recently, "It might interest you to know that in the last ninety days, over ninety foreign stations have gone on the air in an effort to control communication—the wireless communication of the world. The United States has placed two on the air. . . . Now it is a fight to get there first. We file or preëmpt in Berne the channels that we think we are going to use, but what counts are the channels that are actually put to beneficial use."

Communications are the nerves of commerce and commerce is the life of nations. Permitted unrestricted growth as private enterprise, American communication companies have made excellent progress in establishing a world-wide communication system (see March of Radio, March, 1928); but we are now entering a new phase of the situation, a bitter war of competition between telegraph and radio interests, further complicated by the ambitions of the host of interests desiring to establish private services. This era of competition should be considered not only in the light of its national importance but for its bearing upon the position of America in international communications.

The keenest competitors for radio territory are Great Britain and the United States. And Holland has not been backward; it looks upon radio communication not only as a medium of commercial exchange but as an ally to maintain unity with her far-flung colonists by means of short-wave rebroadcasting of programs originating from the mother country. Germany also has ambitious plans, already well under way, for an international system of high-speed telegraph, radio, and picture transmission.

The present enviable position of American international communications, now threatened by politics and bitter competition, is as much attributable to former political meddling in England as it is to American commercial and scientific progressiveness. The stage is now set to repeat in the United States all the mistakes Britain has made, just at a time when it may seriously injure our position in the world of the ether. For Great Britain has now attained that solidarity in wireless communications control the lack of which gave the United States an opportunity to come to the front; and we have arrived at a point where internal conflict is becoming a serious impediment to further progress.

Struggles of the British Imperial Radio System

AS EARLY as 1910, a British imperial chain to link the dominions with radio was discussed. The Imperial Conference in June, 1911, recommended a state-owned system of communications and a contract to put it into operation was signed in July, 1913, after protracted negotiations with the Marconi Company. The World War prevented further progress with the plan, which would have placed British interests supreme in the field of communication. In 1919, another imperial wireless telegraph committee was appointed, which drew up a plan for a chain system of stations separated by about 2000 miles. Still another committee was appointed in December, 1920, to carry out the plan.

The colonies, however, grew restive at these costly delays and several negotiated directly with the Marconi Company for the erection of stations to link them with the mother country. These independent measures confused the imperial scheme. With the coming of the coalition government in 1923, the imperial plan was again shelved and private enterprise encouraged. After months of negotiation with the Post Office Department, however, the Marconi Company failed to obtain a satisfactory license to enter the field, with the result that still another Commission was appointed, headed by Sir Robert Donald, Chairman of the Council of the Empire Press Union. Its report, made in February, 1924, resulted in a contract with the Marconi interests for the erection of four beam stations to link England with South Africa, Australia, and India. Construction was begun in April, 1925, and service within two years. A traffic totalling 35,000,000 words annually is now being handled.

But even this is not the end of the story. After paying regular and substantial dividends for decades, the British international cable system, erected largely with capital supplied by the government and the dominions, was turned into a losing proposition by radio competition. Still another government commission was appointed with a view to protecting this immense investment and working out a traffic division or merger agreement with the radio interests. Fearing further government blunders, the two interests worked out a merger agreement, announced March 15 of this year. The problems of political interference and cable competition having thus been solved by amicable adjustment, British interests are now forging ahead untrammeled.

The Mackay-R.C.A. Struggle

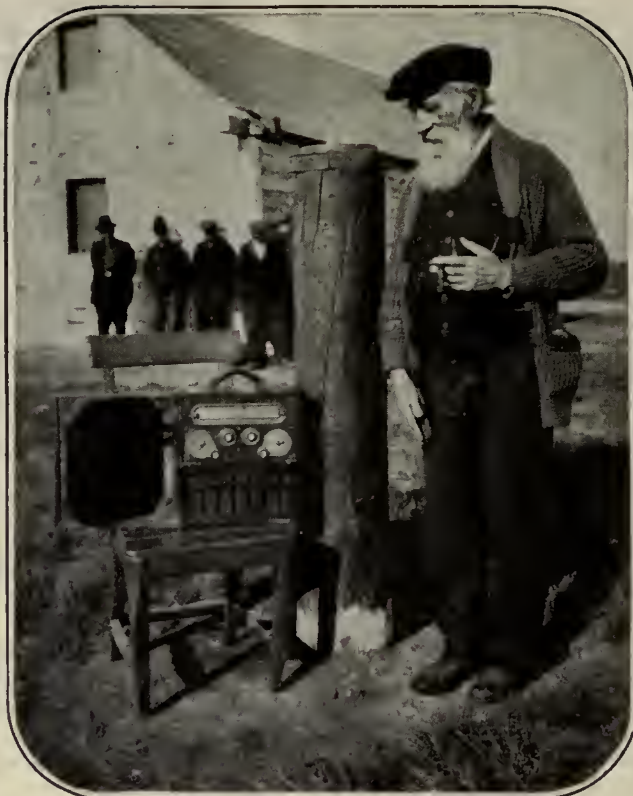
IN THE United States, the Mackay interests, seeking to protect their cable investment, have embarked upon an ambitious plan to compete with the Radio Corporation in the field of communication. The R. C. A., in turn, has attempted to step into the overland communication business as a competitor to the telegraph. To that end, it has applied for construction permits to erect 65 short-wave transmitters for a domestic service linking 24 cities. At the same time, the Mackay interests are seeking to establish their own national radio system as a supplement to wires. Furthermore, powerful newspaper interests are laying plans to establish their own independent national and international communication systems and have been granted 20 of the 22 channels which they sought by the Federal Radio Commission. On all sides there is effort to duplicate facilities, many of which, experience has shown unmistakably, are unprofitable if competitive.

We are opposed to a communications monopoly, although economic considerations require that no services be paralleled or duplicated unless traffic warrants. The Federal Radio Commission requires the wisest possible counsel if it is to avoid endangering the American position. International communication is a semi-public function and can be regulated to secure the advantages of monopoly without permitting its abuse. We have the most efficient telephone system in the world because it is monopolistic. We also have the lowest telephone rates, and they will remain the lowest because we have the power of regulation through public service commissions.

THE CONTROL ROOM OF A COMMERCIAL TRANSMITTER

This array of meters and tuning controls regulates the short-wave transmissions of the San Francisco station of the Federal Telegraph Company. The control room is located at Palo Alto, California

A working agreement among telegraph and radio interests is essential to our future in international communications. No one should be excluded from the field who can contribute needed service. The vast system of message collection and distribution of the established telegraph system must be made available to radio, and the revenue equitably divided so that cable, telegraph, and radio can continue to operate profitably without destructive competition. If such agreement is not equitably worked out by the interests involved, government meddling, with its paralyzing influence, will follow. If the problem is tackled with a spirit of conciliation, there is ample room for both the Mackay and the Radio Corporation interests. The American position in international communications is threatened by a destructive warfare of rival interests.



A RADIO DÉBUT IN THE FAR NORTH

Old John Furth, Hudson's Bay factor at Fort McPherson, Mackenzie, Canada, is listening in on KGO *as picked up by the portable receiver which Lewis R. Freeman carried on his expedition in Canada. Furth is standing by a sun dial erected one hundred years ago by Sir John Franklin, the Arctic Explorer*

The Commission Announces Its Short Wave Policy

THE Federal Radio Commission on May 24 allocated 74 short wave channels for transoceanic services, as follows:

Robert Dollar Company, 8 channels; Tropical Radio Telegraph Co., 7; American Telephone & Telegraph Company, 9; American Publishers Committee, 20; the Mackay Company, 15; Radio Corporation of America, 15.

These assignments were made on the basis of a statement of principle adopted by the Commission: "That competitive service be established where there are competing applications to compete with already established service, and that in the grant of competing licenses fairness of competition be established, except that as to an isolated country, which in the judgment of the Commission will not afford sufficient business for competing wireless lines, only one grant of license shall be made, preferably the first application in priority."

The table on this page shows the number of transoceanic channels in use, applications made, approved, and totals in use.

How closely the Commission has adhered to the excellent principle which it has enunciated cannot be judged without knowledge of the specific purposes for which these applications recently approved are to be put. Perhaps in the most doubtful category are the assignments made to the newspaper publishers, inasmuch as most of their services are likely to duplicate existing facilities. The communication companies, so long as their own applications are granted, are not likely to oppose the assigning of channels to the press which, through its public influence, can embarrass them and which, from the revenue standpoint, does not make a desirable customer because of the special rates applying to its needs.

CALDWELL HITS STRAIGHT FROM THE SHOULDER

ACCUSTOMED as we are to soothing propaganda from the Federal Radio Commission, it gives us no little pleasure to report as fully as space permits the remarks of Commissioner O. H. Caldwell, delivered through WOR on May 22.

After pointing out that the Davis Amendment must be enforced and that it offers an opportunity to better conditions for the listener, Mr. Caldwell continued: "Indeed, it is no longer a secret that certain members of Congress, after having secured the passage of the Davis-Dill Amendment hardly six weeks ago, would to-day like to see its enforcement indefinitely postponed, now that they have discovered what will be its effects on the various states (and their own political reputations) when actually applied. . . . The outpourings of a few self-seeking politicians on the menace of high power; tedious legal theories; convenient states' rights arguments borrowed to cloak promoters' profits; or the necessity for Podunkville to have a 1000-watt transmitter which can specialize only in phonograph records and county political oratory —these topics all have very little concern for Mr. Average Listener if only the wavelengths of the great popular stations he dials to, nightly, can be kept clear so that their splendid programs can be received as unspoiled and perfect as when they left the studio. That much, and only that, do the millions of radio listeners really ask of their Congressional representatives, their Federal Radio Commission, and their Government at Washington. And it is high time that they got it.

"What the public itself has been demanding—and has a right to expect from the Commission—is prompt relief from the unhappy radio reception conditions which still persist, and have rendered large parts of our radio spectrum useless, particularly to distant listeners on farms, ranches, and in remote communities.

"The station over which I am speaking, WOR, now recognized as one of the great program sources of the country, frequently has its splendid programs ruined at some places within 30 to 35 miles of Newark and New York by the heterodyne moans and howls produced from another station on the same wavelength, WOS, in Missouri. Meanwhile, WOR inflicts similar interference on the good people of Missouri. The other popular 5000-watt New Jersey station WPG, at Atlantic City, is similarly spoiled at any distance by several Middle West stations—which, in turn, it similarly injures.

"In New York City, reception from WNYC is continuously ruined by a Chicago station; WHN is blasted by transmitters in Louisiana and Iowa; and WABC is injured by cross talk from an adjoining channel. Even WEAF and WJZ suffer Pacific Coast whistles on winter nights.

"In Philadelphia, the popular pair WFI and WLIT are badly heterodyned, right within the city limits, by carrier-waves from Minnesota. In Boston, WNAC has a background of growls which come from Pittsburgh. Massachusetts' big 15,000-watt WBZ station shares its wave with eight other stations, affording the farmer who tries to tune in on its agricultural programs all the variety of howls and roars incident to feeding time at the zoo. And this enumeration of particulars in the listeners' bill of complaints might be extended almost throughout the whole 89 wavelengths.

"This is the real situation which the Commission was created to correct, and which the millions of the public have patiently waited to have remedied. This is the situation of nightly interference which will again be upon us in September, after the summer static has rolled away.

"It can be remedied only by reducing the number of stations permitted to operate simultaneously on the air during night hours. The re-

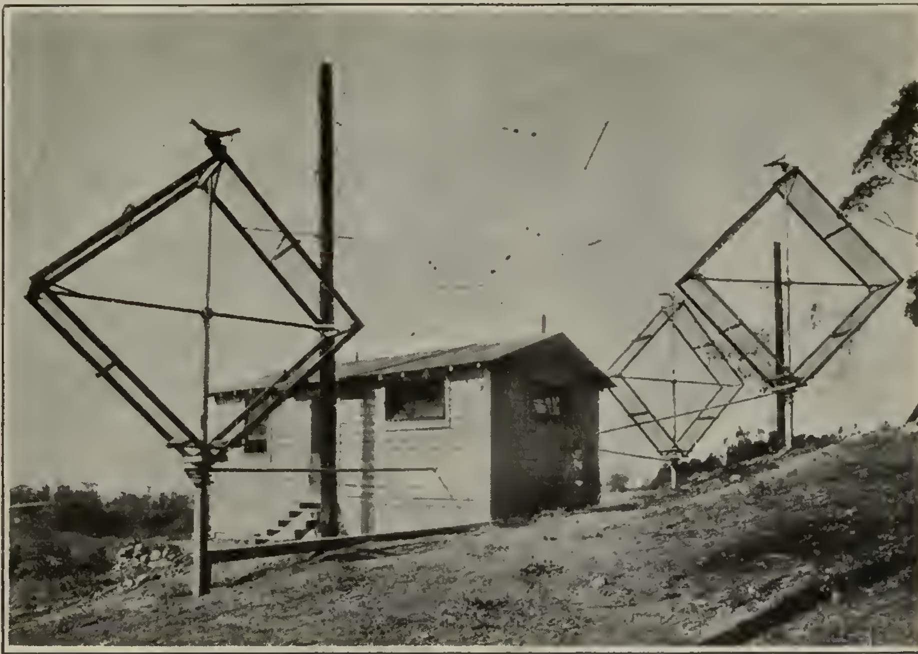
Short-Wave Transoceanic Assignments in the United States

	Now using	*Applied for recently*	*Approved*	*Total assigned*
Pacific Communications Co.		8	0	0
Robert Dollar Company		15	8	8
Tropical Radio Telegraph Co.		12	7	7
American Tel. & Tel. Co.	3	9	9	12
American Publishers		22	20	20
The Mackay Company	22	19	15	37
Radio Corp. of America	50	55	15	65
TOTAL	75	140	74	149

quirements are well known to all radio engineers. We have only 89 wavelengths. For good radio, not over 160 stations of the 500-watt and 5000-watt classes can operate simultaneously on 85 of these wavelengths. On the remaining four wavelengths we can tuck in a couple of hundred 50 or 100-watt transmitters. And there you have the outline of the possibilities in the present state of the art."

No more courageous and clear cut statement has ever emanated from the Federal Radio Commission. It must not, however, be regarded as anything more than the statement of one Commissioner who understands the situation and is in favor of carrying out his duty. It can be fairly charged that the majority of the Commission is totally lacking in ability and courage and has utterly failed to protect the interests of the listener whom it is supposed to serve. So long as the local interests of politicians and the short-sighted demands of individual broadcasters have the ear of the Commission rather than the radio audience at large, the present confusion will persist. Mr. Caldwell's is a voice crying in the wilderness. More power to it!

On May 27, the Federal Radio Commission promulgated its Order No. 32, the first drastic measure to reduce the number of stations on the air. It lists 162 broadcasting stations which must sign off August 1 unless they can show good reason for renewal of their licenses. A careful scrutiny of the list shows that many of the stations have been inactive and that it comprises only stations of a very low order of merit, occupying extremely congested channels. While the number of stations involved is considerable, this is only a first step, which will bring very little noticeable relief. It does not attack congestion of the type to which the Commissioner referred, involving stations rendering important service. The real problems of the Commission will not begin until it disposes of stations of some technical ability which serve no real program purpose. But the measure is a good beginning which, we hope, is only the first of a series of major steps to relieve broadcasting congestion.



WHERE SHORT-WAVE MESSAGES ARE RECEIVED

The barrage antenna and receiving shack are part of the Federal Telegraph Company's station near Los Angeles, California. Coastwise and marine commercial radio traffic is carried on by short waves

AMATEURS IN THE TEN-METER BAND

C. K. ATWATER of Upper Montclair, N. J., has been successful in establishing two-way communication on 10 meters with 6ANN, Long Beach, Cal., 6UF, Los Gatos, Cal., and 8CT, Arachon, France. Commenting on this remarkable achievement, the American Radio Relay League stated that the ten-meter band might yet prove of actual worth in long distance transmission of messages by radio and that experiments by amateurs might ultimately solve many difficulties on this band hitherto considered insuperable by communication engineers.

There is no justification whatever for the statement that engineers consider the difficulties to the utilization of super short waves insuperable. We refer the amateurs to a paper by Marconi, *Proceedings of the Institute of Radio Engineers*, August, 1922, describing experiments conducted over a period of years on wavelengths between 1 and 20 meters. Since that time, continuous research work has been conducted on ultra-high frequencies in many professional laboratories. Several international commercial circuits operate regularly on 11 meters, and no communication engineer who has worked on high frequencies has ever made a statement justifying the A. R. R. L's boast. The amateur is to be commended for his experiments, but the statement that he is pioneering in the ultra-high frequencies, spurned by engineers, is not supported by the facts.

Here and There

A WIRELESS station is being completed at Horta, Azores Islands, by the Portuguese Government for the purpose of radiating detailed weather reports four times daily. It will be of special service to transatlantic aircraft.

THE National Broadcasting Company has formed the National Broadcasting and Concert Bureau, with George Engles, former manager of the New York Symphony Orchestra, as its managing director. The National Broadcasting Company now arranges 5,000 microphone appearances each month.

STATION WGY, on April 30, rebroadcast a program radiated from 2FC, Sydney, Australia, on a 28.5 meter wavelength. H. M. Myers of Birmingham, England, reports an amazing feat of international reception in which 2XAF, WGY's short-wave sister, participated. Tiring of local programs, Mr. Myers tuned to Stuttgart, Germany, then rebroadcasting 2XAF. The Schenectady announcer informed his audience that a program from London was coming in so well that 2XAF would rebroadcast it. The Britisher listened to the London program to the end, setting his watch by Big Ben, after the signal had made two trips across the Atlantic. Distance lends enchantment!

A FLYING description of the parade in honor of the Bremen crew was broadcast by WOR on May 6 with the aid of an announcer aboard a plane. A short-wave transmitter, working on 65.48 meters, utilizing two 210 tubes, served the transmitter.

THE Crosley Radio Corporation, operating WLW, has obtained control of WSAI, U. S. Playing Card Co., of Cincinnati. It hopes, by combining these two stations, both of which have a cleared channel, to secure an exclusive channel for the proposed 50,000 watt WLW transmitter.

STATION WOO, pioneer Philadelphia broadcaster, operated by the John Wanamaker store since 1922, signed off June 1. "Investigations made by special inquiry among radio listeners during the past two years have revealed that broadcasting is not helping the store in general or in an advertising way, hence our decision to discontinue operations indefinitely." Hundreds of stations, making a similar impartial investigation, would come to the same conclusion. Maintaining a broadcasting station is a costly operation, and a single retail organization can no longer justify the expense of running a full time station by the resultant good-will and sales.

PERMALLOY SAVES THE CABLE COMPANIES

IN a paper appearing in the April, 1928, issue of the *Bell System Technical Journal*, entitled "High Speed Ocean Cable Telegraphy," O. E. Buckley discloses the progress made in high speed cable communication, largely attributable to the use of permalloy loaded cable. The first of these cables was laid in September, 1924, between New York and Horta, and there are at present seven high speed permalloy loaded ocean cables, totalling 15,000 miles in length. Their capacity is 2,500 letters per minute. Mr. Buckley's conclusion is that "permalloy loading has so reduced that part of the total cost per word for which the cable itself is responsible that the advantage of radio can never be very great. It has yet to be shown that radio telegraphy can furnish as reliable and satisfactory service as is now provided by the cables. . . . It is evident that only a much higher degree of perfection of radio communication than has yet been attained can permit wresting from the cable the advantage which it has so long maintained."

THE New York Central Railroad has asked the Commission for short-wave telegraph assignments in order that it may equip some 300 small harbor craft with radio telephony of low power. Successful experiments in communication between engineer and conductor of long freight trains will sooner or later require additional channels for the railroads. Inasmuch as

DX WITH A HOME-MADE LOUD SPEAKER

The improvised loud speaker on top of the radio was made from a camp-fire reflector and an old baking powder can. It helped the members of the Harmon-Freeman Expedition in the Canadian Rockies to get the play-by-play account of the World Series in New York

these services are all of low power, but few channels will be required.

THE Federal Radio Commission was allowed an appropriation of $301,467 by Congress, an amount larger by $149,067 than was allowed by the Budget Bureau. The Chairman of the Commission indicated that it would employ one chief attorney and two assistants, five radio experts and several examiners. Next year, they will ask for an office building, a larger staff and a million dollar appropriation. The Commissioners ought to be hired on a piece-work basis, so much per station eliminated with a bonus for each channel cleared. General Order No. 32 would give it a good start for the year.

GERMAN radio exports during 1927 were valued at 33,426,000 marks, of which about one-tenth was shipped to Belgium, France, Italy, Jugoslavia, Roumania, and Japan as war indemnity. Shipments to the United States were valued at 1,066,000 marks.

THE British Postmaster General has authorized the erection of a new, high-power, twin wavelength station in London, to be erected for the British Broadcasting Company. It will be in service in twelve to fifteen months.

AN ADVISORY Committee to the League of Nations has recommended the construction of a $250,000 wireless telegraph station with an estimated operating cost of $40,000 annually. Its estimated traffic is valued between $20,000 and $30,000.

SENATOR DILL now offers a new substitute for his S. 2783, to the effect that it shall be considered complete defense in an infringement suit to prove that the complainant is a party to an agreement, cross license or understanding with any patent holder which tends to lessen competition or create a monopoly. The proposal is of doubtful constitutionality, but it may help the Senator in his forthcoming campaigning back home. As Heflin hates the Pope, Dill hates the R. C. A. Why not propose to repeal the patent law? It is distinctly in restraint of trade and creates legal monopolies. At least such a proposal would be straightforward and could be fairly judged on its merits.

THREE radio beacons have recently been placed in operation on Long Island Sound by the Lighthouse Service of the Department of Commerce. They are at Execution Rocks Lighthouse near Hell Gate Bridge, at Stratford Shoals Light, and at Little Gull Island.

IN LINE with the policy of conserving frequency space, the number of naval stations has been reduced from 167 in 1921 to 78, and further reductions, to be in effect by June 30, 1929, will bring the number to 72. Traffic continues to grow, the 1927 total being 75,296,500 words, as compared with 55,779,900 in 1927 and 53,102,900 in 1925. During 1927, 40,000,000 words were handled for the Navy, 13,000,000 for other Federal departments and 9,000,000 words of commercial and press traffic.

IN SPEAKING of the newly formed American-Baird Television Corporation, formed by Messrs. Herbert Pokress, Charles Izanstark and Nathan Feldstern, Sir Charles Higham, one of the British stockholders and a well-known advertising man, stated: "In my opinion, television will work a decided advantage in the advertising methods of the new world. The greatest difficulty heretofore encountered by manufacturers has been to give the consumer his first view of the product. People are curious as to the various ways of making things, and rightly so." Mr. Baird's television apparatus is no exception to this rule.

LIONEL BARRYMORE is quoted, in an interview granted in Chicago, as saying that television will scrap the theaters throughout the country. That's what they predicted electricity would do to gas, the telephone to the telegraph, and radio to the movies. Even should television rise to such heights that it has entertainment as well as scientific value, it can never replace mass entertainment presented in person by capable actors.

STATION WRNY will send television images under the supervision of Theodore Nakken. Transmissions will be at the rate of 10 images per second and consequently are restricted to very slow motion. The inventor claims that the station's 10 kilocycle channel will not be exceeded. Observers of WGY's 380-meter television signals report that they trespass far into neighboring channels, although these consist of only 24 lines.

EXPORTS of radio apparatus during March amounted to $858,302, an increase of $199,830 over the same quarter last year Argentina exceeded Canada as our best market for the first time during the month of March.

THE Lektophone Corporation has licensed the United Radio Corp. of Rochester, makers of Peerless speakers, under the Hopkins patents.

AN APPLICATION for a patent on a variable condenser, so shaped as to give a straight-line frequency effect, was denied as lacking "the dignity of an invention" and the decision of the Commissioner of Patents to that effect was sustained by the Supreme Court.

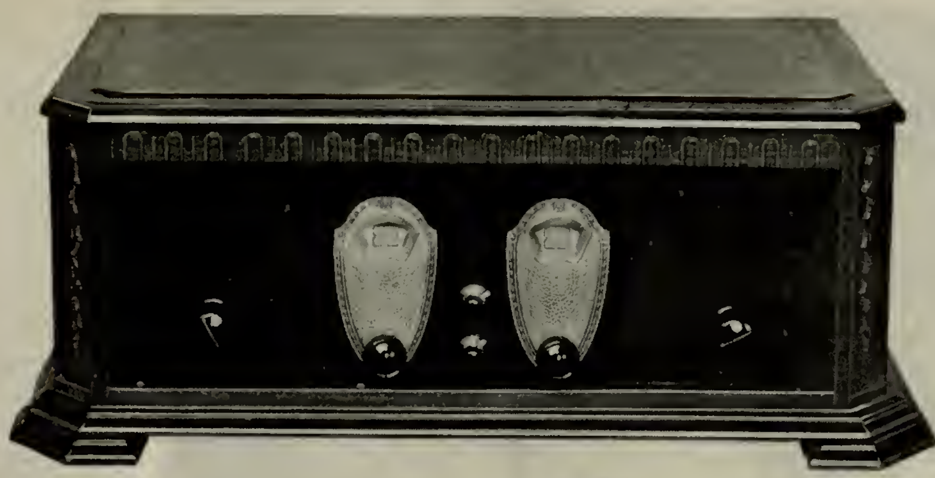
—E. H. F.

RADIO ON TRAINS

SINCE the Delaware, Lackawanna & Western began experiments with radio communication in 1913, considerable progress has been made in the art. Ford installed radio transmitters along the Detroit, Toledo & Ironton, but three years later abandoned radio in favor of a newly completed telegraph and telephone system. The New York Central began its experiments in coöperation with the General Electric Company in 1924, and highly practical apparatus has been developed for conversation between caboose and engine. On Election night in 1924, three eastbound and three westbound sections of the Twentieth Century Limited were equipped with receivers. The Great Northern began its work in 1925, but concluded that its telephone and telegraph equipment was adequate to meet its dispatching needs. The Canadian National Railways has erected ten broadcasting stations and has equipped a number of its de luxe trains with headphone installations. In Germany, several fast trains are equipped for radio telephonic conversation linked with the land line system. It is successful for trains traveling at speeds up to 45 miles an hour. Several English trains are equipped for broadcast reception for the benefit of passengers. Broadcast reception aboard trains is subject to constant intensity variations and, until we have automatic fading compensators, it is not likely to be generally adopted.

STATION WMCA and the stations associated in its chain began a regular schedule of Rayfoto broadcasting on May 23.

THE A. T. & T. has applied for the necessary channels to inaugurate a short-wave, single side band radio telephone service between New York and Buenos Ayres. —E. H. F.



THE PANEL IS SIMILAR TO THAT OF THE A. C. MODEL

Building the D. C. Lab Receiver

By Keith Henney

Director of the Laboratory

THE differences between the R. B. Lab Circuit receiver described by Hugh S. Knowles in the June RADIO BROADCAST (p. 93) and the model described in this article are few; the present receiver uses standard d.c. tubes of the 201A or preferably the 112A type (because of their better detection and amplification characteristics), while the June receiver was designed to use a.c. tubes. The same placement of parts is followed, the parts themselves are the same; the circuit diagram has not changed. The only differences are those incidental to the use of the a.c. type of tubes. Some readers prefer the newer tubes, others prefer battery-operated tubes. It is probably true that thousands of RADIO BROADCAST's readers have d.c. tubes on hand to hundreds who have 226's and 227's, and there are many who still have faith in the old storage-battery-charger outfit—the Staff of RADIO BROADCAST Laboratory among others!

Briefly, the circuit is the R. B. Lab that was first described in June, 1926, and brought up to date in the April and June issues of this year. Readers who are not familiar with its advantages and its theory are urged to get those copies. It is only necessary to state here that it is a four-tube receiver consisting of a stage of neutralized radio-frequency amplification followed by a grid leak and condenser type of detector with capacity feed-back, and a two-stage transformer-coupled amplifier. It is the standard circuit to which all others are compared in the Laboratory. Any other receiver which, regardless of the number of tubes, can get signals of equal strength out of weak distant stations, is considered a good receiver. The chances are that such a receiver is subsequently described for the benefit of our readers.

Fig. 2 is the circuit diagram of this receiver, operating with d.c. tubes. It requires less apparatus than the a.c. receiver, since the C-bias resistors which are used in the a.c. set to give the tubes the required grid voltages are not necessary. Provision is made for an external C battery to perform the same purpose in this model. In Fig. 1 is a top view of the d.c. set. It will be seen that exactly the same placement of parts as was used in the a.c. model is followed. Where the filament transformer of the a.c. set was placed, an output device, such as a condenser-choke or an output transformer may be located and, if desired, a C-bias resistor for the power tube may be placed beside it where the low voltage C-bias apparatus was installed in the a.c. set. Naturally, four-prong tube sockets will be used instead of five-prong or Y type sockets. An on-and-off switch has been included and should be installed on the panel—above the phonograph switch is a good place.

IF THERE is any way we can know exactly what the readers of RADIO BROADCAST *want, we should like to find that way. For months we promised another article on the Lab Circuit receiver. For the June number we got Mr. Hugh Knowles to build us a receiver with all modern improvements, a.c. tubes, etc. Immediately we received complaints that what was wanted was a d.c. Lab Circuit article. Here it is. Almost the same list of parts is used, they are placed in the same postion on the baseboard, and their functions are the same. The differences in operation and dx getting ability are too slight to be noticeable. In favor of the a.c. set is the freedom from battery troubles; in favor of this receiver is the greater freedom from power noise. Battery operation also has in its favor the feeling shared by many radio experimenters that the a.c. tubes may not last as long as their older brothers, the battery operated tubes.*

—THE EDITOR.

The phonograph switch, Sw_1, makes it possible, as Mr. Knowles has already explained, to throw the audio amplifier of the receiver from the set itself to a phonograph pick-up unit without the usual bother of removing the detector tube from its socket in order to place in it the plug which goes with all modern types of pick-up units. In other words, the plug is permanently installed in the extra socket, V_5, the cabinet is closed, and all bother has been eliminated.

COILS FOR THE LAB CIRCUIT

ALTHOUGH special coils are being manufactured for this receiver, many experimenters prefer to wind their own. The simplest method is as follows. Procure two coil forms 2 inches in diameter. Wind on both forms 75 turns of about No. 24 wire. The insulation and exact size of wire in not important. The coils will then tune over the broadcast band with 0.0005 mfd. condensers. For the antenna coil wind about ten or twenty turns about the exact center of one of the coils which has been tapped at the center turn for the C bias of the r.f. tube. This constitutes the coils, L_1 and L_2, in Fig. 2. The other coil is tapped at about the 25th turn, or if other size winding forms are used with different numbers of turns, tap the coil at about one third of its length. The smaller part of the coil goes in the plate circuit of the r.f. tube; the detector input voltage is that appearing across two thirds of the coil. Experimenters who wish greater selectivity, with somewhat less amplification, can reduce the number of turns in this plate coil, say to 15 in a 75 turn coil, that is, increase the turns ratio to 5 to 1.

NEUTRALIZING THE R.F. AMPLIFIER

THIS amplifier differs from the usual stage of r.f. amplification in being neutralized by the Rice system. When the circuit has been properly wired up, make the detector oscillate by varying the regeneration condenser; tune-in a fairly strong station; then, when the carrier whistle can be easily heard, vary the tuning condenser setting of the r.f. tube. Probably this will force the detector out of oscillation with a thump or a swish or a squeal. Turn the neutralizing condenser until this stoppage of the detector oscillations does not take place. When the amplifier is properly neutralized, changing the amplifier tuning condenser setting will have little or no effect upon the detector circuit. It is not important to worry about this neutralizing business. It may be impossible to neutralize the amplifier exactly so that it has no effect on the detector, due to extraneous couplings between the two circuits—magnetic via the coil fields, resistive via common batteries, or capacitive, through the other elements in the receiver. The important adjustment is that which enables any frequency to be tuned to without the amplifier going into oscillation or preventing the detector from tuning properly. This adjustment is easy to find.

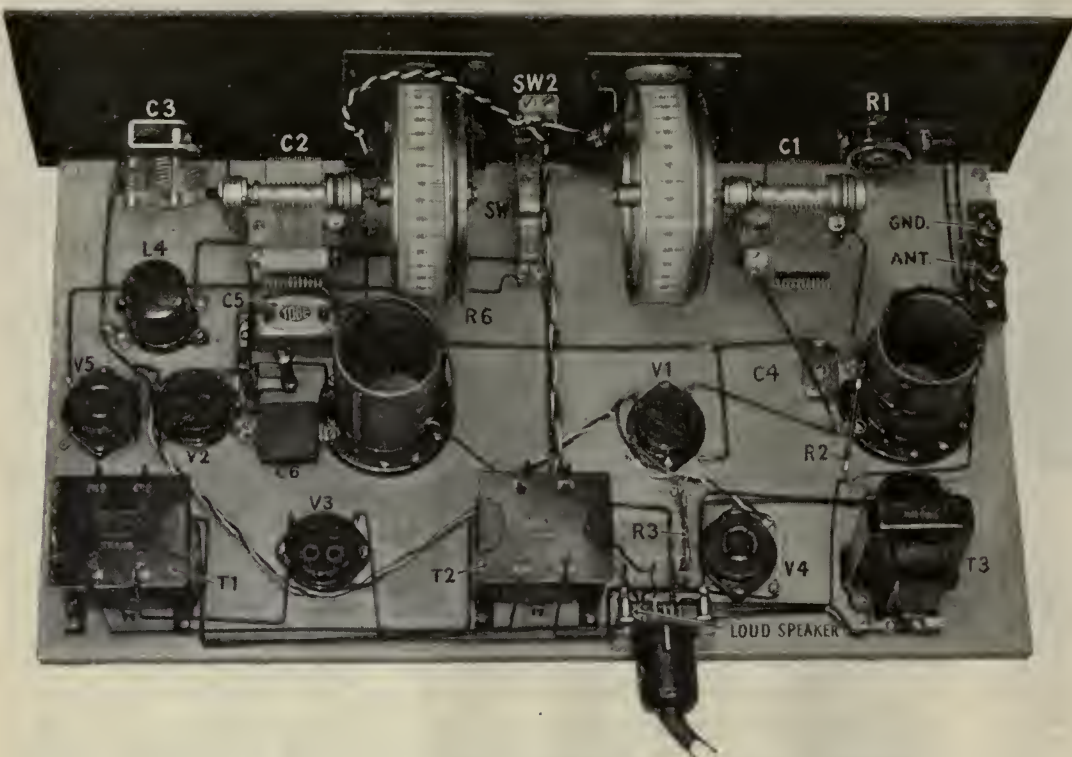


FIG. 1. THE TOP VIEW

Because the Rice amplifier has both the stator and rotor plates of the tuning condenser above ground potential—neither is grounded—some hand capacity may be evidenced. The easiest method of preventing such trouble is to use insulated shafts. Fortunately the Hammarlund condensers used by Mr. Knowles have removable shafts. It is a simple matter to put in a hard rubber (or other insulating material) shaft in place of the metal ones supplied by the manufacturer.

PANEL LAYOUT

A PICTURE wiring diagram and panel layout sheet may be obtained by writing to Radio Broadcast, Garden City, N. Y. The parts list on this page gives the apparatus actually used in the receiver. Similar parts may be used, of course. The only special apparatus is the coils, which may be built at home if desired.

WHAT BUILDERS THINK OF THE LAB CIRCUIT

SINCE the first appearance of articles on this circuit in Radio Broadcast, many readers have written of their experiences. The first of the letters quoted below is typical. It comes from a man of about forty who sells locomotives—we cannot, we regret, publish his name.

For your personal information, I take the occasion to write you that your last edition of the "Lab Receiver," as shown in April issue, far excells anything I have ever experienced in radio receivers.

I had a set built according to earlier issues, mounted in a handsome console with illuminated dials (Hammarlund), and coupled to a Western Electric 25" cone. Till recently I thought I had perfection.

However, I built a set for a friend as shown in the April Radio Broadcast, using Thordarson R-200 transformers and bypassing only the first B lead with a 2 mfd. condenser and audio choke. I used 3 112A's and a 171A. Both sets have the r.f. and detector stages in 6" x 10" copper boxes.

This last set was more selective, sensitive, and gave far better tone quality. I put up two grounds and aerials and ran both on the same station, using the 25" and 18" Western cones, switching the cones. If this last set had fit my console I surely wou d have passed the old set on.

I was able to bring in Toronto with no interference from KDKA or WHT—and I am close to WHT. KOA, WSMB,—and others came in strong, clear, and without distortion. Not so on the earlier model. I could not get Toronto. You see I had two complete outfits—speakers, power units, aerials, and grounds. I tried to make a fair and intelligent test of the two sets. With the later set I actually tried to get interference on the lower waves on the locals. It couldn't be done.

The letter below is from Alfred V. Waller who lives in Halifax, Nova Scotia:

Just a line to let you know that I have been an R. B. Lab. Circuit fan since June, 1926, and can say there is no outfit to come near it in performance, or in any way, for that matter. I've tried everything up to 8 tube supers, but the R. B. Lab. tops them all. On the speaker I've had over and over on good nights KFI, KGO, CNRV, CZE and every other 10 kc. from 200 to 545.

LIST OF PARTS

- C1, C2—2 Hammarlund ML-23 condensers
- C3—1 Hammarlund MC-15 midget condenser
- C4—1 Hammarlund equalizer
- C5—1 Tobe 1.0-mfd. bypass condenser
- C6—1 Aerovox 0.00025-mfd. grid condenser
- L2, L3—1 pair Aero coils, type RB 8
- L4—1 Hammarlund choke, RFC-85
- R1—1 Electrad volume control, type P
- R2—1 Electrad grid resistor, 500 ohms
- R3—1 Frost deluxe resistor, 1 ohm
- R6—1 Durham grid leak, 2.0 megohms, with mounting
- SW1—1 Yaxley s.p.d.t. switch No. 30
- SW2—1 Yaxley s.p.s.t. switch No. 10
- T1, T2—2 Silver-Marshall audio transformers, No. 240
- T3—1 General Radio output transformer, type 367
- 1 Westinghouse Micarta panel, 7" x 21" x 1/8"
- 1 Yaxley cable and plug, No. 669
- 5 Eby 4-prong sockets
- 2 Eby binding posts
- 2 National single drum dials
- 2 Coils of Celatsite hook-up wire
- 2 lengths of 1/4" bakelite rod.

The additional parts necessary to make the set operative are three 201A or 112A type tubes and a 171 type for the last audio stage, a loud speaker, and A, B and C batteries or power supply units. The receiver will give best results with an outdoor antenna, 75 or 100 feet long.

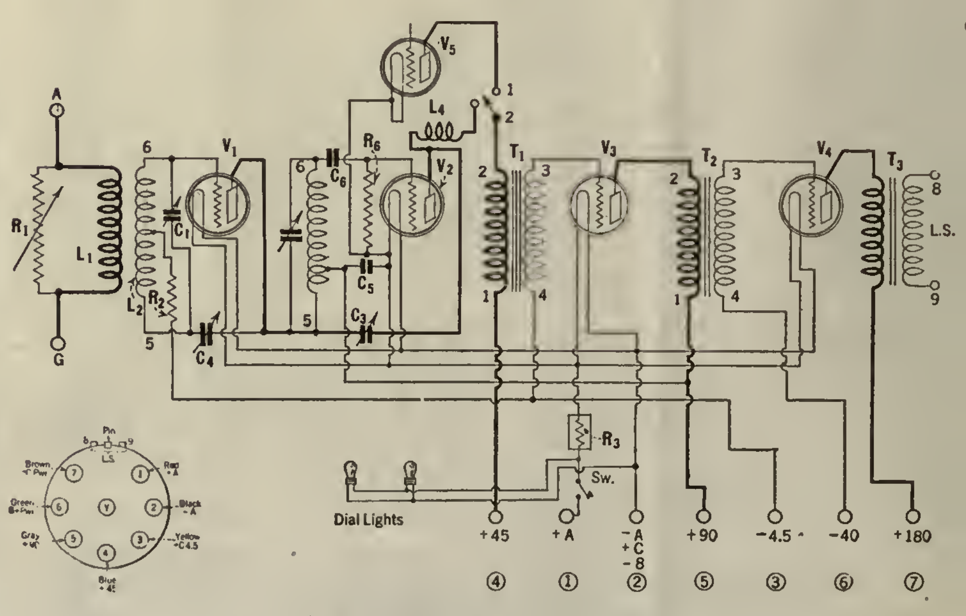
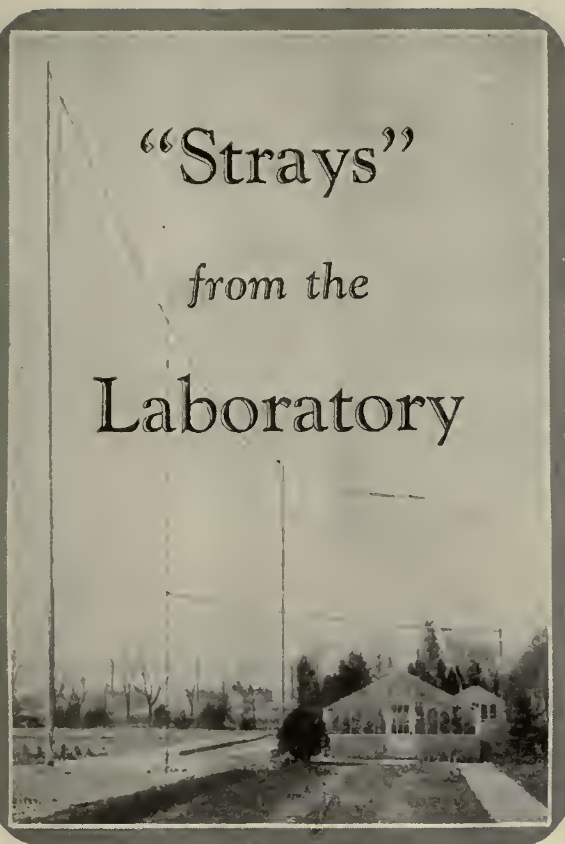


FIG. 2. THE CIRCUIT DIAGRAM

The detail diagram at the lower left shows the proper connections to the cable plug

"Strays" from the Laboratory



Keeping r. f. current out of the audio

The presence of radio frequency currents in the input of an audio amplifier is always to be avoided; they tend to make the amplifier overload more easily, promote troublesome hand capacity, and invite a lack of stability. In the February 1st issue of the *Wireless World*, A. L. M. Sowerby discusses this problem and suggests the use of a resistance in the grid circuit of the first a.f. tube, as shown in Fig. 1-A. and the equivalent circuit in Fig. 1-B. Here the resistance, R, is the external series resistance, C is the effective input capacity of the tube, which under operating conditions is much greater than the capacity as measured when the tube is cold.

At radio frequencies, without the external resistance, considerable voltage may be developed across the input capacity. With the resistance, however, this voltage is divided between that lost across the resistor and that appearing across the capacity. It is only the latter that is passed into the amplifier. If the impedance of R is greater than that of C, less voltage will appear across C. The following formula gives the ratio between the applied voltage and what actually gets to the input of the amplifier,

$$\frac{E_0}{E} = \sqrt{1+R^2\omega^2C^2}$$

and the following table gives the result of using an external resistance such that the product of R and C is 10, when R is in megohms and C in mmfd. Such a product reduces audio notes of 5000 cycles only 5 per cent., which is permissible.

Frequency	Per cent. Radio Frequency Remaining
1500 kc.	1.0
1000	1.6
750	2.1
500	3.2
300	5.2
150	10.5
50	30.0

This shows that on the broadcast band, the r.f. currents can be cut down to a permissible figure without greatly decreasing the high audio notes at the same time. But in super-heterodynes operating at 50 kc. such discrimination is not sufficient; 30 per cent. of the r.f. remains and appears across the amplifier. Here a low-pass filter is necessary.

What values of resistance and capacity should be used? Mr. Sowerby states that the effective input capacity of most tubes is about equal in mmfd. to eight times the amplification factor of the tube. This gives the following effective input capacities of American tubes, and using this figure we arrive at the values of resistance given. These resistors need not carry much current; in fact, if the amplifier is properly designed and operated the current that passes will be negligible.

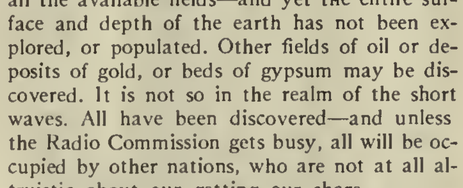
Tube type	Amp. factor	Effective capacity	Resistance ohms
171	3	24 mmfd.	300,000
201-A	8	64	150,000
199	6	36	30,000
112	8	64	150,000
210	8	64	150,000
Hi-mu	30	240	40,000

The Short-Wave Market

Many people seem to wonder at all the excitement about the allocation of frequencies in the short-wave spectrum. This is probably because the uninitiated ones do not know that a license to operate a station below 100 meters is about as unique a franchise as has ever been granted. We often hear that there are no more lands to be developed, that nations must find some way to utilize the Arctic, that the nitrate beds are all doled out, that the oil interests have gobbled up all the available fields—and yet the entire surface and depth of the earth has not been explored, or populated. Other fields of oil or deposits of gold, or beds of gypsum may be discovered. It is not so in the realm of the short waves. All have been discovered—and unless the Radio Commission gets busy, all will be occupied by other nations, who are not at all altruistic about our getting our share.

Once assigned, and with a station operating on a channel, say at 40 meters, the story is told. Any other station of equal power will interfere. Nothing that man has as yet discovered will alleviate the situation. In other words, nothing is so rare as a short wave; it is truly unique. It is like a rare Mauritius postage stamp—we know how many were issued in the year 1847, we know where these stamps are, and nothing can be done about it. No wonder the price is high.

We listen in at infrequent intervals to the short-wave stations, hammering out ultra fast commercial traffic, facsimile transmissions, television signals, shooting shafts of highly concentrated beams of electrical energy at Canada, South Africa, Australia. Nearly every time we listen we discover a new station; one of the blank spots on our dial has been filled. There are only a few left.



(A) (B)

FIG. 1

And yet the Radio Commission bewails the fact that in all the short-wave ether there are only places for 200 stations and they already have applications for 300 from this country alone. What is to be done?

Not long ago we were called on the phone by a brokerage firm operating branch offices in all the larger cities of the South and Southwest. Their bill for wire lines was about $100,000 a year. Wouldn't short waves cut down that cost? They had heard that a short-wave station could be built for $1000; that the upkeep was small. Would we consider a consulting job of equipping this brokerage company with twenty such stations?

The Radio Commission has in its power the issuing of short-wave licenses, the most valuable pieces of paper in modern time. What are they going to do about it?

"Sink or Swim" Tube Testing

It has been our intention for some time to mention the excellent "Laboratory Broadcasts" which appear in the Hartford (Connecticut) *Times*, a column or two of radio ideas, gossip, popular explanations of what happens in your receiver, etc. L. W. Hatry, who has written for Radio Broadcast as well as other radio publications, is the author; he has had occasion to mention the Laboratory, and the writer, for which we thank him. He has recently discussed hard and soft tubes and states that a good test for a soft tube is to give it 100 or more volts—on the plate, we assume—and if it turns blue internally, it is soft. Which reminds us of the way we used to determine whether a small boy could swim or not. We threw him into the creek, and if, after counting up to a hundred, we pulled him off the bottom and found that he was blue in the face, couldn't tell his name, couldn't walk, couldn't even breathe—we assumed he couldn't swim.

Can anyone suggest a better test?—we are now referring to Mr. Hatry's method of testing for soft tubes.

Line Voltage Variations

In a recent release from the Radio Corporation of America, Doctor Alfred N. Goldsmith is quoted as stating that there is no serious line voltage problem. He is speaking of this non-existent problem—according to him—because many a.c. sets have caused no end of trouble due to tube failure, when excessive line voltage variations caused the voltage across the a.c. tubes to average too high a value for long tube life. Doctor Goldsmith's statement was based on a series of tests made in the New York metropolitan district, where the power companies spend much money to maintain their voltages constant at the consumer's home or plant.

So we took an a.c. voltmeter home, plugged it into the socket and made readings at various times during the day and night. The average voltage was 110, the highest recorded was 113, and the lowest 105. Apparently, the people who generate and distribute power to this part of Long Island (Garden City) take as much care to maintain good lines and good voltage regulation as they do in the city.

But we wonder what happens out in the smaller towns, at some distance from cities, say in places with about 35,000 population? How great is the voltage variation there? Is it within

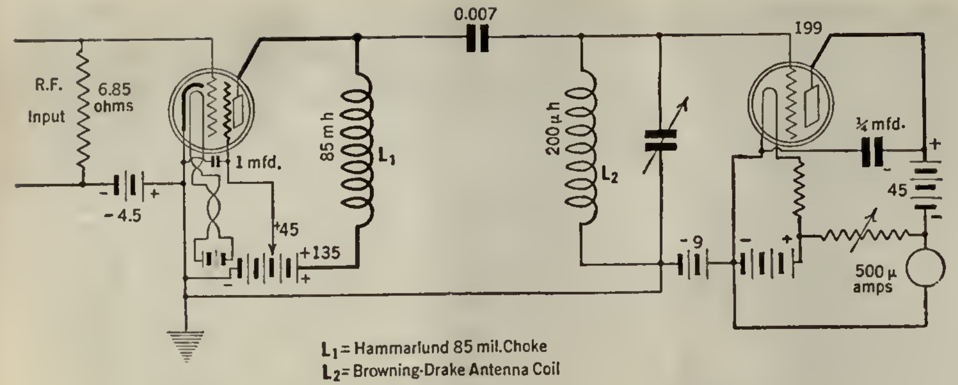


FIG. 2

the 5 per cent. that the R. C. A. engineering and test department found to be true in Manhattan?

A. C. Screen-grid tubes MANY experimenters have been hoping for a.c. screen-grid tubes. The following data is the result of some measurements in the Laboratory on several tubes of this type. The filament is the standard 2.5-volt, 1.75 ampere heater type with the accessory plate and grid structure around it as in the d.c. tubes. Under normal conditions of screen and plate voltage, we obtained an impedance of about 375,000 ohms and a mutual conductance of about 500 micromhos.

Realizing that the most experimenters prefer actual gain measurements to those on the tubes' constants, we hooked up the circuit shown in Fig. 2 and secured a voltage gain as shown below.

Frequency	Voltage gain
500	40
580	41
660	48
940	80
1050	120

The coil and condenser unit was standard Browning-Drake apparatus used as the input to an r.f. amplifier tube. The inductance was 200 microhenries and at 500 kc. the combined coil and condenser had a resistance of about 5 ohms. These values of resistance and inductance indicate a theoretical voltage gain at 500 kc. of about 56.

It should be noted that a resistance input was used, and that d.c. was used to heat the heater. The effect of a.c. when this tube is used in an actual circuit has not been determined, although reports indicate that it makes an exceptionally good high-frequency amplifier, the question of selectivity remaining where it was when recently discussed in these pages.

"Strays" from other Laboratories LAST month we quoted some strange business about a loud speaker test that took place in one of our contemporaries' laboratories. During the test the output current from the amplifier ran as high as 49 milliamperes, and from 1200 to 1280 volts appeared somewhere in the circuit without the necessity of calling out the fire department. The following statement appeared recently in another radio publication: "The Raytheon BH rectifier tube is now tipless, increasing rating to 125 MA."

We feel the prize, however, for technically inaccurate statements appeared in still another radio paper a year or so ago. An author was describing a world-beating receiver consisting of one or more r.f. stages coupled to each other by means of transformers. Figuring that the usual voltage gain in a neutrodyne stage, which has 60 turns on the secondary and 6 on the primary of the interstage r.f. transformers, was 10, this writer suggested using only one primary turn, when the voltage step-up would be increased from 10 to 60 per stage!

The field for one's imagination in radio is apparently unlimited.

Making D. C. Sets Comfortable SEVERAL months ago we mentioned the fact that we saw little reason why anyone should throw away a good battery-operated set in favor of an a.c. receiver, when the former only required about eight minutes a week to place the battery on charge. Mr. Beecher Ogden, of Pleasantville, New York, forces us to admit that we have no simple device for doing this work for us, and that we still get down under the table, fuss around with wires, get hands and knees dirty, and get into a generally bad humor—at least once a week. Mr. Ogden's scheme for preserving one's friendliness toward the battery-operated receiver is illustrated in Fig. 3. It consists of a switch which throws one battery on the set and another on charge—or if one has only one battery, a simple d. p. d. t. switch will throw the battery from the receiver to the charger, which may be connected into a base-plug or any other source of a.c. Say Mr. Ogden:

> I am shocked and grieved at the implied admission on page 352 of RADIO BROADCAST for March, second paragraph, that you still have to disconnect the battery from the set to put it on charge, for I can't figure any other way that could possibly take eight minutes a week. RADIO BROADCAST has described several switching arrangements that certainly don't need five seconds to put the battery on the charger. However, here is a real one that has been in use for years. Take a four-pole d. t. switch and cross-connect it on the back so that one battery is on charge and another on the set at the same time. A 2-ampere Tungar will give you about 30 a.h. a day, which should be enough.

Loud Speaker Tests THE following letter from a Norfolk, Va., radio enthusiast speaks for itself. It describes the result of two very interesting tests on loud speakers, and calls attention to the dynamic type which has been mentioned more than once in these columns.

> I read with interest your department's comments on recent developments in loud speakers under "Strays from the Laboratory" in the February issue. Your readers appreciate the necessity of protecting your advertisers, but information of that nature based on the results of comparative tests in the Laboratory are of the greatest value to your readers. I hope you will continue to give us the results of your tests.
>
> I have followed the development of loud speakers for a number of years, and have known that the Western Electric has been generally favored for monitoring work in the control rooms of broadcast stations. I have had occasion to compare this speaker with others before an audience composed of people with trained musical ears and technical knowledge. The loud speakers were arranged behind a curtain so that the audience would not be prejudiced by preconceived opinions. Seventy per cent. rated the W. E. first on music, and 90 per cent. rated it first on voice. The same experiment was tried with an audience composed of people none of whom had had a musical education or technical training. Practically everybody in this audience preferred the RCA model 100-A over all other speakers on music, and they were about equally divided between this speaker and the W. E. on voice. These experiments were performed under conditions of ideal local reception, that is, without heterodyne squeals or static. Under conditions of distant reception with heterodyne squeals, background noises, and static present, almost everyone agreed that the RCA model 100-A was to be preferred to the Western Electric. In other words, the high-frequency cut-off filter incorporated in this (RCA) speaker which eliminates the greater part of these interfering noises is certainly desirable under present broadcast conditions even at the slight sacrifice of clearness of speech which it entails.
>
> I have been testing out a Magnavox dynamic power cone under various conditions of baffling, recently, and I am surprised that you did not mention this speaker as being one of the best of the new speakers in your article on this subject. The power handling capacity of this speaker is so far superior to that of other types that it is a little difficult to make comparisons. A 5000-cycle cut-off filter effectively eliminates heterodyne squeals and background noises. On some nights when static noises are so loud on the Western Electric that reception is unsatisfactory, the Magnavox brings the music in clear with a minimum of interfering noises. Of course, this is accomplished at a slight sacrifice in "intelligibility."

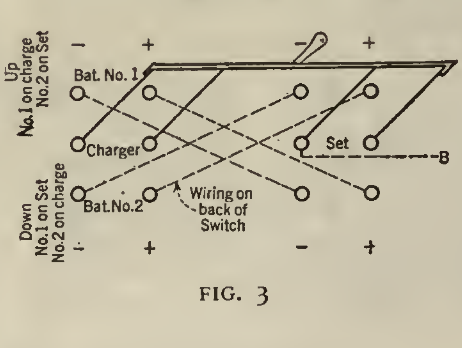


FIG. 3

Recent Articles of Interest WE HAVE read with considerable interest the following articles in various radio and technical publications:

Amplification Behind the Talking Movies, *Bell Laboratories Record*, May.

Loud Speakers of High Efficiency, *Journal of the A. I. E. E.*, April.

Getting Started at 30 Megacycles, *QST*, May

Practical Audio Filters, *QST*, May.

Amplification and High Quality, *Wireless World*, May 2nd.

The Earth as a Magnet, *Scientific American*, May.

Geophysical Prospecting, *Scientific American*, May.

The Inverted Vacuum Tube, *Proceedings of the I. R. E.*, April.

The Development of the 250 type tube, *Proceedings of the I. R. E.* April.

Broadcast Control Operation, *Proceedings of the I. R. E.*, April.

A CABINET MODEL OF THE SHORT-WAVE RECEIVER

The short-wave set shown above uses the same parts and employs the same circuit as the receiver described in this article. It differs only in the aluminum panel and shielding used; these are obtainable through Silver-Marshall, Inc., or may be home constructed

A Screen-Grid Short-Wave Receiver

By Howard Barclay

THE tremendous interest in short-wave reception which has been sweeping the country of late has brought about a great change in the requirements of a good short-wave receiver. The old-style short-wave receiver of the "ham" days, while still as sensitive as ever for c.w. work, has proved inadequate for receiving the modulated signals of telephonic broadcasts with the smoothness and quality of the reception obtainable in the higher broadcast bands. The short-wave receiver described in this article provides this higher degree of performance, plus freedom from radiation, for the oscillating detector is isolated from the antenna by a screen-grid r.f. amplifier tube. This tube does not add a tuning control, its input circuit being untuned, yet it improves the reception of telephone signals, and entirely eliminates "dead spots" at which the set will not oscillate, since it effectively isolates the antenna from the sensitive detector circuit.

An unusual degree of smoothness of regeneration control, freedom from "putting" and "fringe effect" noises as the set goes into oscillation is effected by careful circuit and coil design, notably by using a small coil, which on the lower waves, particularly around 20 meters and below, provides smoother and sweeter control than the two- three- and even four-inch short-wave coils generally used. The coils are actually a refinement of the popular "tube base" or "Scottish" idea which has been found to give such excellent and economical results. These forms are slightly larger and longer than the average tube base, making it possible to design more efficient coils than are possible on the ordinary tube base (often not available except at the expense of breaking good tubes). A winding space $1\frac{1}{2}''$ long and $1\frac{1}{2}''$ in diameter is available, with a tickler slot $\frac{1}{8}''$ deep and $\frac{1}{16}''$ wide at the filament end. On the bottom of the moulded form are five hollow lead pins, properly positioned to fit any five-prong a. c. tube socket. These coil forms are so cheap that any number of experimental coils for different wave bands can be wound at little cost, to be tuned by any size of condenser that may suit the builder's fancy. In this matter of "builder's fancy," however, it is well to remark incidentally that while a code receiver can be thrown together almost any old way and still work, physical placement of parts and wiring details must be most rigidly watched in order to get a good modulated signal receiver. In the set described, the tickler condenser hardly reacts at all on tuning, over 20 degrees at 40 meters being needed to tune a c. w. code signal out of "readable" audibility.

THE short-wave receiver described in this article employs a screen-grid tube as an r. f. amplifier and incorporates an audio system that amplifies high quality signals without distortion. It was designed in the Research Laboratories of Chicago for Silver-Marshall, Inc., and uses a new and ingenious type of coil wound on a form that fits into a five-prong or Y type of tube socket. In the Laboratory the receiver seemed remarkably free from the noises which often ruin short-wave reception, and on the sometimes swinging, sometimes steady signals of 5SW in England we received good dance programs from the Savoy Hotel in London.

—THE EDITOR.

CONSTRUCTION OF THE RECEIVER

THE set illustrated is mounted on an 8 x 18 x $\frac{1}{2}''$ seasoned wood baseboard, with all parts placed in a simple straight line as shown in Fig. 1, instead of being tied up in a knot (as in broadcast band receivers) difficult of assembly and "trouble shooting." In Fig. 1, at the left is the antenna choke coil L_1, next the screen grid r.f. tube socket, then the five-prong coil socket up on 1" studs, next the grid condenser, C_1, and grid leak mounting, detector tube socket, plate r.f. choke, L_3, and the two audio tube sockets, with a pair of flat characteristic 3:1 transformers, T, behind the a.f. tubes. At the rear are the Fahnestock connection clips, and on the front panel are the .00014-mfd. tuning condenser, C_4, the 20-ohm detector filament rheostat, R_2, and the .00035 tickler condenser, C_5. The circuit diagram, giving the proper connections, is shown in Fig. 2.

The matter of a good short-wave variable condenser is an interesting one, for few good broadcast condensers, even of properly reduced capacity, are good at 20 meters and below, where bearing noises develop to an annoying degree. A noisy broadcast type of condenser can often be quieted for short-wave work by insulating its bearings, at increased cost and labor. However, the type of compression bearing found in the General Radio and Silver-Marshal condensers is quiet at 20 meters, and offers all the advantages of a good mechanical bearing of

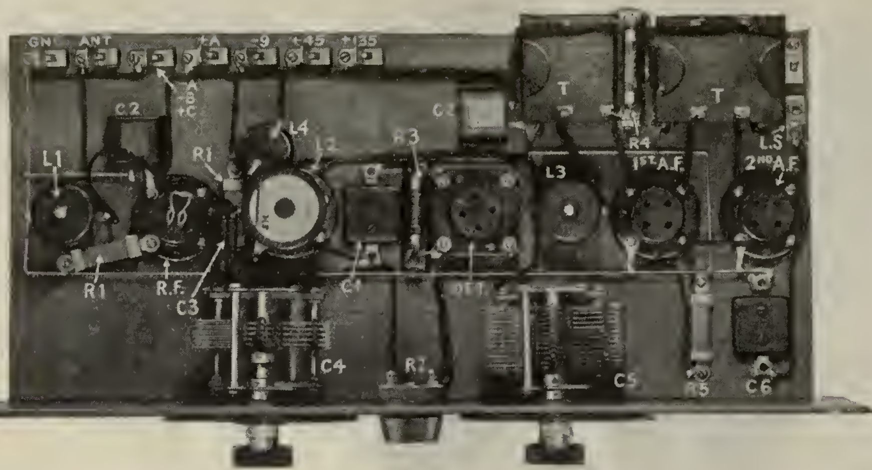


FIG. 1

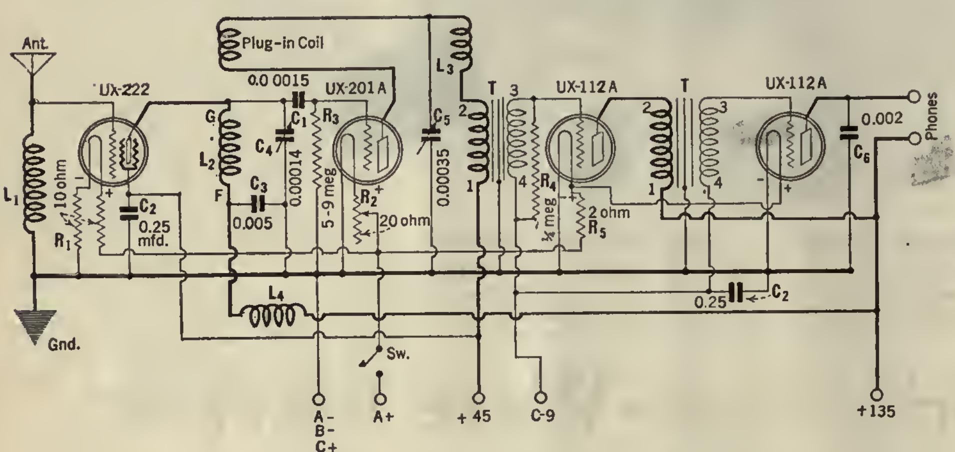


FIG. 2

brass and steel. This feature of quiet bearings may be possessed by other types on the market as well.

In building this type of set, the parts should be placed just about as shown, so that a short direct ground line can be run in from the antenna choke, along the back of the variable condensers and over to the a.f. transformer frames, which must be grounded. All wiring should be short, direct and well soldered, and care should be taken to avoid the possibility of "closed loops" of wiring which would pick up energy and possibly cause irregular regeneration control. The apparently unnecessary bypass condensers, as across the a.f. C battery, C_2, and from the second a.f. tube plate to ground, C_6, should be used; their purpose is to cut stray r.f. currents from the audio amplifier, all in the interest of smooth operation.

The parts used in the model, which was rebuilt several times to make sure that it would go together the same way and with the same results in spite of the minor variations bound to occur in home assembly, are listed at the end of the article. The panel is not a necessity, and can be left off to cut cost, if appearance is not an object. Everything else is quite important to smooth performance, though fixed condensers, sockets, and such parts might be substituted if on hand. Unless you are only interested in code reception, do not substitute for r.f. chokes, coil form size and variable condensers unless willing to "smooth up" your own particular set's operation by the "cut and try" scheme of adding bypass condensers, r.f. chokes, and resistors at needed points.

The coils are all wound on the same type of Silver-Marshall form, with No. 34 d. c. c. wire for the ticklers, and No. 22 enamelled wire for the secondaries (except the 104.0–204.5 meters coil, which used No. 24 d. c. c.) All secondaries have turns so spaced that the windings cover the full 1½" of form space. The windings are so connected that the top or start of the secondary terminates in the G post of a standard 5-prong tube socket and the bottom or end in the right hand F post (the F post nearest the P or plate post). The slotted tickler, wound in the same direction, starts at the "F" post nearest the "C" or cathode post and ends at the "P" post.

The number of turns necessary to cover the four bands from 17 to 240 meters are given below, using a 0.00014-mfd. condenser and a 0.00035 mfd. tickler condenser.

COIL DATA

Type	*Wavelength Range Meters*	*Secondary*	*Tickler*
"T"	17.5—32.1	6½ turns	5½ turns
"U"	30.7—59.0	13½ turns	5½ turns
"V"	57.2—110.0	25½ turns	9½ turns
"W"	104.0—204.5	49½ turns	15½ turns

OPERATION

THE tuning curves for a particular set of four coils are given (Fig. 3) as an aid in finding stations when the set is first operated, and it will be seen that the amateur wave bands fall well away from the ends of the condenser scale, so that with good vernier dials no difficulty is had in tuning amateur code signals.

To duplicate the curves given, it may be necessay to trim coils a bit once they are wound, but this is easily done, or coils simply rewound on the small Bakelite forms. Coils of fewer or greater numbers of turns for other wave bands can be quickly wound for the "tube base four" as the set might well be named.

The operation of the set is simple, almost any antenna from fifteen to fifty feet giving quite good results; even a long broadcast antenna does not seem to destroy the sweet control of the set. Any good storage battery, nine volts of C battery and 135 volts of B battery (or as low as 90 will do) are all that is necessary for operating power.

Socket-power units are generally noisy on short waves and are not to be recommended. If a B-supply unit is used, a 45-volt battery should be supplied for the detector plate voltage. This will cut down the noise appreciably. Two 112A audio tubes, a 201A detector, a 222 screen grid r.f. tube, and phones or loud speaker are also necessary.

LIST OF PARTS

THE coils are the only special parts employed in this receiver, and the data for them is given above. Parts of similar characteristics may be substituted for all the other apparatus mentioned in the list below.

- C_1 —1 Condenser, .00015 mfd.
- C_2 —2 Condensers, ¼ mfd.
- C_3 —1 Sangamo condenser, .005-mfd.
- C_4 —1 S-M condenser, .00014 mfd., type 317
- C_5 —1 S-M condenser, .00035 mfd., type 316-A
- C_6 —1 Condenser, .002 mfd.
- L_1, L_3—2 S-M short-wave chokes, No. 227
- L_4 —1 S-M short-wave choke, No. 275
- R_1 —2 Yaxley resistors, 10 ohms
- R_2 —1 Yaxley midget rheostat with switch, 20 ohms
- R_3 —1 Lynch resistor, 5 to 10 megohms
- R_4 —1 Lynch resistor, $\frac{1}{10}$ to ¼ megohm
- R_5 —1 Yaxley resistor, 2 ohms
- T —2 S-M audio transformers, type 240
- 2 National vernier dials
- 4 S-M blank coil forms, type 130
- 4 S-M tube sockets, type 411
- 1 S-M five-prong socket, type 512
- 2 Lynch resistor mounts
- 9 Fahnestock clips
- 1 8" x 17" x ½" wood base
- 1 7" x 18" x ⅛" micarta panel
- Screws, nuts, hook-up wire, solder, lugs, etc.

If factory wound coils are preferred instead of winding coils at home, one each of Silver-Marshall 131 T, 131 V, 131 U and 131 W coils may be obtained. The amount of wire needed for a set of home-made coils is given here.

- ½ lb. No. 22 plain enameled wire
- ¼ lb. No. 24 double cotton covered wire
- ¼ lb. No. 34 double cotton covered wire

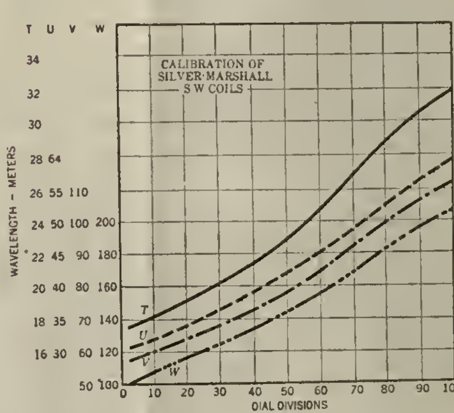


FIG. 3

These tuning curves were obtained with coils mentioned in the lists of parts. Home-made coils can be made which will give similar results

No. 3 RADIO BROADCAST'S HOME STUDY SHEETS August, 1928

Testing Vacuum Tubes

THERE are very few radio receivers nowadays that do not employ one or more vacuum tubes. Many receivers use as many as ten of them; the average in the United States is probably five per receiver. Experiments on such tubes engage part of the time of every serious student of radio because they are the heart of all of our modern circuits and equipment utilizing those circuits. To understand something about the characteristics of such tubes we shall need the following:

LIST OF APPARATUS

1. Source of current, dry cells or storage battery.
2. A rheostat, such as the Frost 20-ohm type 720.
3. A voltmeter, preferably a double range instrument, reading up to 10 volts on its low scale, and up to 100 or more on its second scale. A good one is the Weston Model 506 which reads 7.5 and 150 volts, or the Jewell Pattern 77 which has similar ranges.
4. A milliammeter reading about 10 milliamperes full scale. The one used in the Laboratory to perform this experiment was a Weston Model 301. It lists at $8 and is very useful.
5. A source of plate voltage that is variable in steps of 10 or 20 volts up to about 90 volts.
6. A receiving tube, such as a CX-301A.
7. A baseboard made from 5-ply or ⅜-inch stuff and about 6″ x 16″ in size.
8. Fahnestock clips, wire, such as Celatsite or Belden Colorubber.

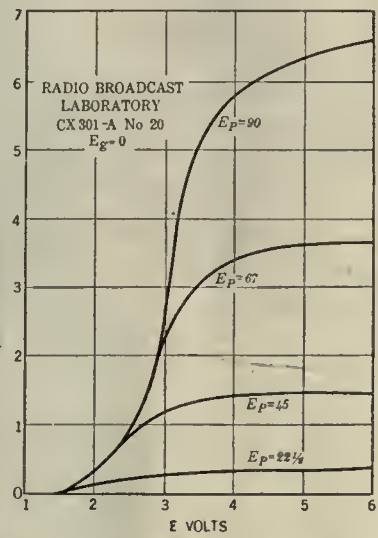


FIG. 1

PROCEDURE

Screw the socket to the baseboard; place the clips in a row along one margin of the board, and mount the rheostat on a small piece of brass strip. If a General Radio or Pacent rheostat is used it can be screwed to the baseboard, and the mounting strip avoided. The connections are shown in Fig. 4, and the experimenter is encouraged to follow out this arrangement of parts since the set-up will be used many times in the laboratory experiments. An hour's time making everything fast and ship-shape according to this layout may save much annoyance later, and possibly prevent a good meter from going back to its manufacturer for repairs. Fig. 3 is a photograph of the set-up used in the laboratory.

Twist a pair of leads, preferably of different colors and about a foot long, and attach one end of the twisted pair to the low voltage voltmeter terminals. Attach the other ends of the pair to the filament terminals on the socket. Make the following connections:

1. Milliammeter between clips 6 and 7.
2. A plus to clip 1.
3. A minus to clip 2.
4. Clip 5 to clip 4.
5. B minus to clip 2.
6. B plus, about 22.5 volts at the start, to clip 8.

A schematic diagram of the above is shown in Fig. 2.

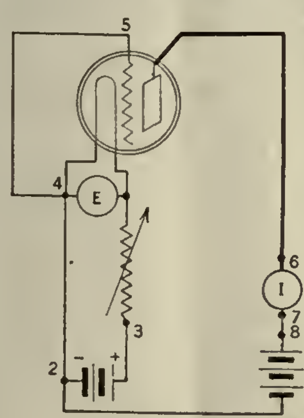


FIG. 2

Turn on the rheostat slowly and watch both filament voltmeter and plate milliammeter. If either reads backwards, reverse the connections to the meter. Note down as in table 1 the plate current as the filament voltage is changed; then turn off the rheostat, increase the plate voltage to approximately 45 and repeat. Repeat for higher values of plate voltage or until the plate milliammeter needle reaches its full deflection. Plot this data as shown in Fig. 1. Remove the voltmeter from the filament terminals and measure the plate voltages applied to the tube in the above experiment by attaching the twisted pair to the high voltage posts of the meter and the other end of the pair of wires to the B minus and the several B plus posts which were used in the experiment.

DISCUSSION

A good description of what happens within the glass wall of the vacuum tube may be found in pages 450 to 470 of the Signal Corps book, *Principles Underlying Radio Communication*. The experimenter is encouraged to read these pages, and to put in his notebook his own digest of the information contained there.

When the filament is heated by the current passing through it, a current begins to flow across the evacuated space between the filament and the positive plate. This current is very small, of the order of thousandths of amperes, or milliamperes. It is carried on the negatively charged electrons emitted from the filament. An ampere is the current carried by 6.28 x 10^{18} electrons per second. The greater the temperature of the filament the greater is the electron stream, and the greater the plate current. Therefore the plate current increases with increase in filament temperature—up to a certain point; then the plate current remains fixed in value regardless of how much the temperature of the filament is increased. This is shown in the curves on Fig. 1. This is known as the saturation effect. The only way to increase the plate current further is to increase the plate voltage, which increases the attraction for the negative electrons and increases the number that arrive per second.

This experiment demonstrates

1. The effect of filament voltage on plate current.
2. The saturation effect at low plate voltages.
3. The fact that under no conditions is there any need or benefit in increasing the filament voltage beyond 5 volts.

The experimenter should explain each of these points in his notebook. These explanations, and the answers to the problems given below, may be sent to the Laboratory, where they will be criticized and returned.

PROBLEMS

1. The d. c. resistance of the tube, that is, the resistance offered to the flow of electrons through the space inside the tube, is the ratio between the plate voltage applied and the plate current (in amperes) flowing; calculate the resistance of the tube for each value of filament and plate voltage applied, and plot against filament voltage.
2. If 6.28 x 10^{18} electrons per second constitute a current flow of one ampere, how many electrons per second make up a current of one milliampere?
3. If power in watts is the product of amperes times volts, calculate the power used up in the plate circuit at each value of plate and filament voltage used, and plot against filament voltage.
4. Where does this power come from? Where does it go?
5. If the average B battery has a life of 5000 milliampere hours, how long should it last furnishing plate current for the tube used in this experiment if the filament voltage is 5 and the plate voltage is 45? If a receiver uses four of these tubes at 90 volts on the plate and one tube at 45 an the plate, all at zero grid bias, how long will the batteries last?

TABLE I

CX 301-A TUBE NO. 20

Ef	Ep = 22	Ep = 42	Ep = 67	Ep = 90
2.0	.15	.2	.2	.2
3.0	.25	1.2	2.25	2.45
4.0	.30	1.4	3.4	
5.0	.32	1.45	3.6	
6.0	.35	1.47	3.65	

Ip

Ef = filament volts
Ep = plate volts
Ip = plate current in milliamperes

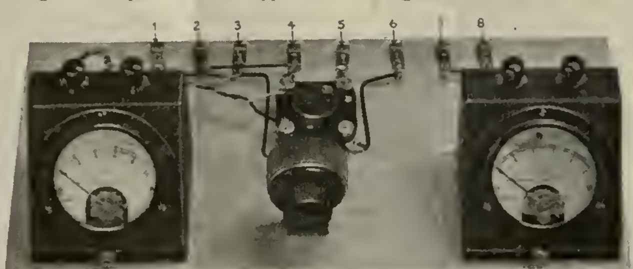


FIG. 3

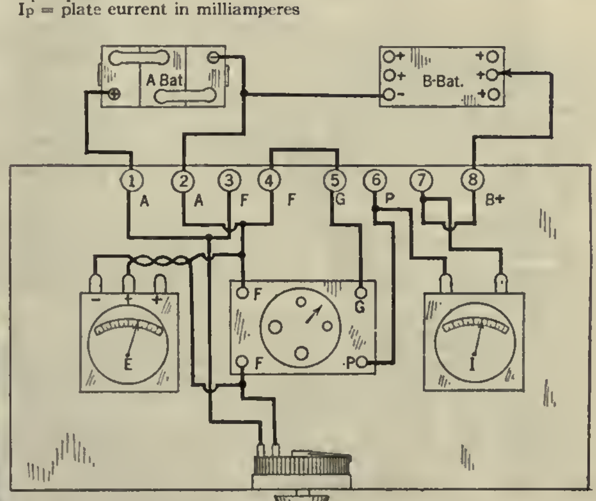


FIG. 4

Ohm's Law

THE most fundamental rule in all electrical work is known as Ohm's Law—from its discoverer, a German experimenter. Previous to its discovery experimenters had only vague notions regarding the amount of current that passed through a circuit under given conditions of voltage and resistance. This law states that in any electrical circuit, the current in amperes equals voltage in volts divided by resistance in ohms.

In electrical language, this means that

I (intensity of current) equals
E (electrical pressure or voltage)
divided by R (resistance)

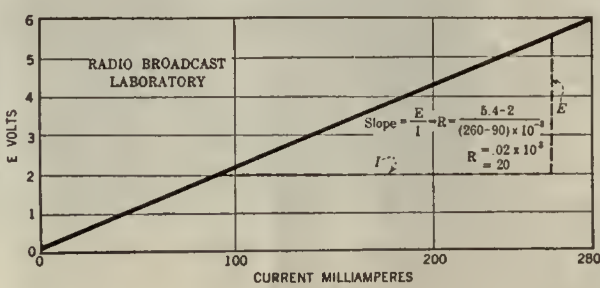


FIG. I

This law may be stated in three ways, viz.,

1. $I = E/R$ 2. $E = I \times R$ 3. $R = E/I$

To get a working knowledge of this fundamental law, we need the following:

LIST OF APPARATUS

1. A source of current, say a storage battery or several dry cells connected in series.
2. Two resistances, about 20 ohms each. One may be a rheostat such as was used in Experiment 2 and the other a similar rheostat or a fixed resistor. The Yaxley 20-ohm De Luxe resistor for example.
3. A voltmeter that will read up to six volts. A Model 301 Weston was used in the Laboratory.
4. A milliammeter reading about 300 milliamperes. The one used in the Laboratory was a Jewell Pattern 54.
5. Hook-up wire.

PROCEDURE

The baseboard set-up described in Experiment 2 may be used for this experiment by connecting the second resistance, i. e. the 20-ohm rheostat or the fixed resistance, R_2, and the voltmeter across the filament terminals of the socket. The connections are shown in Fig. 3, that is, minus A to 3, plus A to the meter and the other meter terminal to 4. The schematic diagram of the set-up is given in Fig. 2.

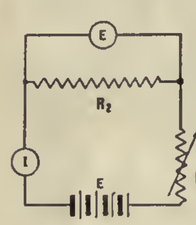


FIG. 2

Turn the rheostat arm *slowly* and note the voltmeter and milliammeter readings. If either reads backwards, reverse the connections to it. Note down as in column 1 and 2 in table 1 the voltage and the current as the rheostat is varied. As a final reading, short circuit the rheostat and allow the full battery voltage to be applied across R_2. Read the current in the circuit. Then remove R_2 but leave the voltmeter across the filament terminals to which R_2 was attached. Read the current flowing now. This is the current taken by the meter.

Using the third way of expressing Ohm's law, viz., that resistance is equal to the voltage divided by the current, calculate the resistance of R_2 and of the voltmeter. Plot on cross section paper as in Fig. 1 the current against the voltage, using the vertical scale for the voltage.

DISCUSSION

The experiment we have just performed is what is known as the voltmeter-ammeter method of measuring a resistance. All that is needed to determine an unknown resistance is to measure the current through it when a known voltage is across it.

The total voltage of the battery has not changed during this experiment, but the voltage across the resistor, R_2, has varied with each setting of the rheostat. What has happened to the remainder of the battery voltage? Clearly it has been cut down by the rheostat, and if we place the voltmeter across this variable resistance as the experiment is repeated, we shall perceive that the total voltage, that is, the voltage lost across resistor R_2 and that across the rheostat, adds up to the terminal voltage of the battery.

Since we know the voltage across the rheostat, that is, the battery voltage minus the voltage measured across resistance R_2, and the current through it (the current in a series circuit such as this is the same in all parts of the circuit) we may use the second method of stating Ohm's law to determine the resistance of the rheostat at each reading in our table and fill in the values.

When the current is plotted against the voltage, a straight line results. The slope of this line, that is, the vertical units divided by the horizontal units, is the resistance of the circuit. If this line did not turn out to be straight, we should have to assume that the resistance of something in the circuit changed with the current through it. This is true of the vacuum tube filament. It has a temperature coefficient, that is, its resistance changes with increase in temperature.

This matter of temperature coefficient is discussed in the Signal Corps' *Principles Underlying Radio Communication* on page 37 in Morecroft's *Principles of Radio Communication* on page 25, in all physics textbooks and in books on electricity.

An "IR drop" is the technical expression for the voltage appearing across a resistance when a current flows through it; it is sometimes merely referred to as a voltage drop. It may be calculated, as may be seen from its name, by multiplying the current by the resistance.

Similarly the value of an unknown voltage may be determined by observing how much current it can force through a known resistance. Thus a meter for measuring voltage, known as a voltmeter, is simply a sensitive current measuring device calibrated in volts rather than in amperes. Throughout an experiment of this kind, and the calculations which go with it, the proper units must be used to make the formula bring the correct answer. The rule uses amperes, volts, and ohms. In this experiment we have used a meter which measures thousandths of amperes, or milliamperes. In order to use the various ways of stating Ohm's Law, we must convert these milliamperes into amperes and then proceed. For example, in the Laboratory the current in the circuit was 94 milliamperes when the voltage across R_2 was 2 volts. In this case one cannot divide 2 by 94 and expect to get an answer in ohms; instead we must realize that 94 milliamperes are 0.094 amperes and divide accordingly.

Thus Ohm's Law, which can be stated in any one of three ways, is useful in determining any one of three fundamental electrical quantities, voltage, current, and resistance.

PROBLEMS

1. Throughout this experiment there have been two "IR" drops in the circuit. Where are they? What should their sums be?
2. Calculate all of the values of current and voltage drops that would exist if R_2 had a resistance of 10, 40, 400 ohms and R_1 were equal to 0, 1, 2 ohms.
3. What current would be taken from the battery if a receiver using five ¼-ampere tubes were operated from it?
4. If the storage battery has a useful life, on one charge, of 100 ampere hours, how long can you operate a five tube (201 A) receiver at three hours per day without recharging the battery?

TABLE 1

E_{R_2}	I	$\frac{E_{R_2}}{I} = R_2$	E_b	E_{R_2}	R_1	R_m
2	94	21.3	4	2		
3	140	21.3	4	1		
4	190	21.0	6	1		
5	236	21.0	6	1		
6	290	20.7	6	0		600

R_2 open, I = 10 = I_m meter current

E_{R_2} = voltage across R_2
I = current in milliamperes
R_2 = resistance of R_2
R_1 = resistance of rheostat = $\frac{I}{E_{R_1}}$
R_m = resistance of meter
E_{R_1} = voltage across rheostat = $E_b - E_{R_2}$
E_b = voltage of battery

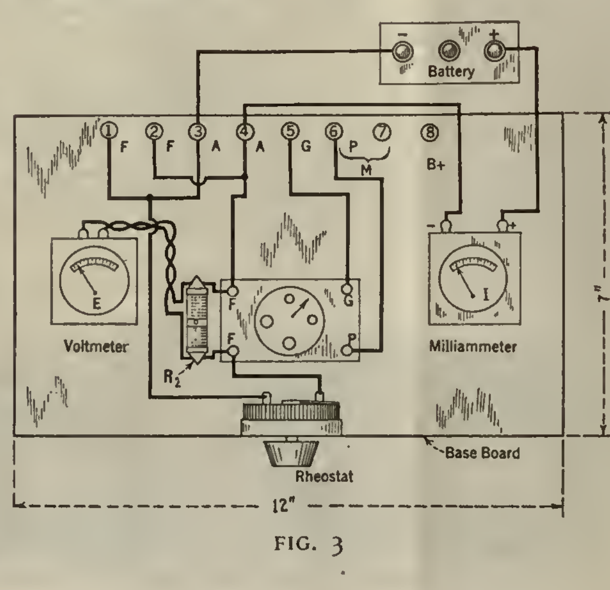
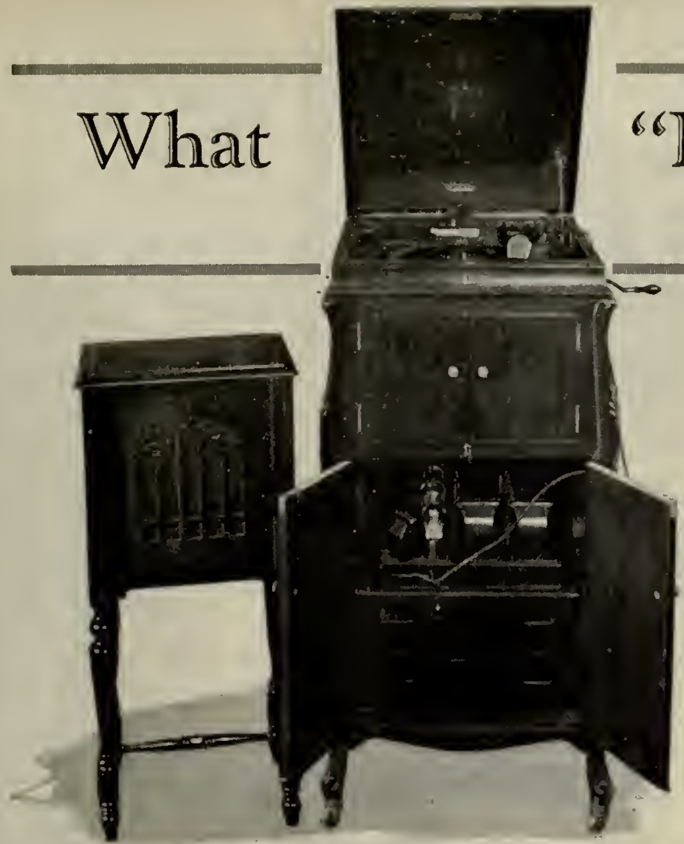


FIG. 3



What "Pick-Up" Shall I Buy?

By David Grimes

Here is an unbiased description of the various manufactured pick-up units now available for modernizing the old-style phonographs with the aid of electrical reproduction and amplification. With the data given here you can choose the unit which best suits your own needs, and provide the accessories which have been proved most valuable in electric phonograph reproduction.

—THE EDITOR.

ELECTRICAL pick-up units first started to appear in radio circles early in 1926. Since then several dozen different types have been manufactured and as many articles have appeared covering their operation. Yet at a recent public demonstration of a particular make in one of the large New York stores, nine out of ten people were amazed that such a device was in existance and, of course, knew much less of its workings. For the benefit of the uninitiated, let it be here stated that an electrical pick-up unit is nothing more than an electrical sound box for your phonograph.

The name "pick-up" unit has been given to that particular arrangement suited for connects ing your old type phonograph with your radio receiver. This has required a few circuit kink which are new, but the fundamental principle employed goes back to the early stage of the telephone and the phonograph. Alexander Graham Bell about 1875 discovered that when a thin piece of magnetic metal was vibrated in front of an electro-magnet, currents were created in the windings of the magnet. These currents were exactly similar in their electrical vibration to the mechanical vibration of the magnetic metal directly in front of the pole pieces of the magnet. Thus, when he talked directly against this thin piece of iron it would vibrate and create currents in the windings of the magnet similar to his voice vibration. This was the first electric telephone.

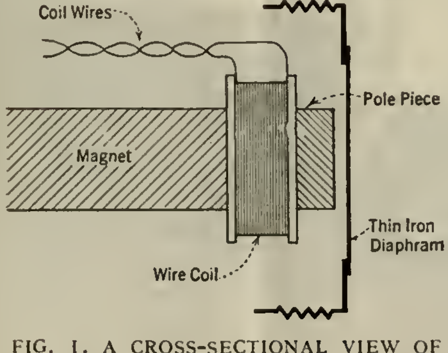


FIG. 1. A CROSS-SECTIONAL VIEW OF AN ORDINARY TELEPHONE RECEIVER

Reference is here made to Fig. 1, which shows a cross-sectional view of the modern telephone receiver with its electrical windings, magnet, and thin metal diaphragm located directly in front of the magnet. But what has a telephone receiver to do with this subject? Bell's first telephone used only one of these receivers at each end. The subscriber talked and listened through the same device, switching it to his ear when he wanted to listen and to his mouth when he wanted to talk. Few people realize that the telephone receiver to-day is practically unchanged from Bell's original conception of the complete electric telephone. As the art developed, other more sensitive principles were used for the telephone transmitter or mouthpiece, but nothing has been found better for the receiver. And even now the receiver, when used as a transmitter, produces better tone quality but less volume than the ordinary telephone transmitter.

We gather from all this that an electro-magnet with a thin piece of iron in front of its poles will act either as a transmitter or as a receiver. You can prove this for yourself at any time by holding your hand over the telephone transmitter and talking to your party at the other end of the line by shouting into the receiver. You will have to talk rather loudly, as the efficiency of this circuit arrangement is quite low, but you will be heard very distinctly at the other end of the line.

Now, Thomas Edison brought out the phonograph a couple of years after Bell's telephone. This was a device which took the minute vibrations of the thin iron disc and, instead of changing them into electrical impulses, recorded them on a wax cylinder which was rotated when recordings were made. This was done by attaching a sharp needle on to the center of the thin disc. This needle cut a waving impression in the wax cylinder as the disc moved to and fro under the influence of the person's voice. Then, when it was desired to hear the record, the thin disc was placed at the end of a horn and the needle was made to travel over the same waving path which it previously had cut. The wax groove forced the needle to and fro, which in turn actuated the diaphragm. Such a device is called a sound-box on the modern phonograph. A diagram of it appears in Fig. 2.

An electrical pick-up unit is merely the combination of these two inventions. A phonograph needle must be attached to the pick-up device. This needle actuates a thin strip of iron mounted directly in front of the pole pieces of an electro-magnet. As the needle is forced back and forth by the waving nature of the grooves of the phonograph record, the thin iron diaphragm is forced to vibrate in unison in front of the electro-magnet. This vibrating magnetic metal induces electrical currents in the windings of the magnet whose vibrations are similar in nature to those of the diaphragm, and in turn to the grooves in the record. See Fig. 4.

Of course, these currents are extremely weak, although very clear and excellent in tone quality. If we should place a pair of headphones across the output of this electric pick-up unit we would hear some very fine music. The only problem

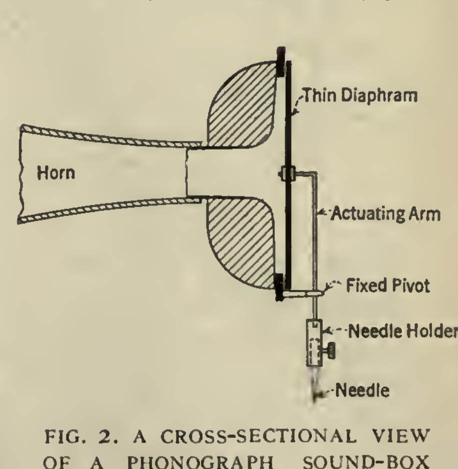


FIG. 2. A CROSS-SECTIONAL VIEW OF A PHONOGRAPH SOUND-BOX

FIG. 3. THE AMPLION REVELAPHONE

that now remains is to amplify this sufficiently to be heard well from the modern loud speaker. Here is where the radio receiver comes into the picture. So far, we have only used the turn-table, motor, and record of the old photograph. The electrical pick-up unit has taken the vibrations off the record and has transformed them into

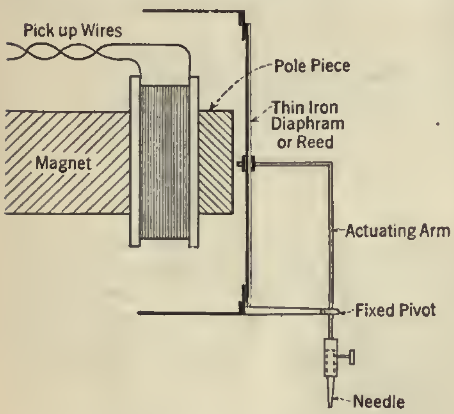


FIG. 4. A CROSS-SECTIONAL VIEW OF AN ELECTRIC PICK-UP UNIT

electrical currents; now they are to be amplified by the radio set.

ONLY THE AUDIO IS USED

THESE currents are not radio currents at all. They are merely the amplified music and voice from the record. Hence, only the audio amplifying end of the radio set is utilized, and the pick-up unit must be so designed as to be readily attached to this audio amplifying section of the radio receiver. The currents are then amplified through the audio amplifier and are reproduced through the loud speaker, just as the radio programs are amplified and reproduced after they are detected by the detector tube. One would guess from this that the pick-up units are attached in some way to the detector tube, at the beginning of the audio amplifier. All of the electrical pick-up units tested in my laboratory operated on this principle. Most of them were arranged to operate in the plate circuit of the detector, although one was arranged to work into the grid of the detector tube and thus gain the amplification of the detector tube.

A careful study of the constructional details of quite a number of different designs shows the necessity of some sort of damping on the vibrating piece of thin iron. Naturally, everything has a natural or inherent period of vibration. Just as a tightly stretched piano string will vibrate at a certain pitch when plucked with the finger, so will the thin iron reed in front of the pole pieces of the magnet tend to vibrate at some particular pitch whenever it is set in motion. If this were not damped or stopped in some way the unit would rattle on certain notes and blast and distort the music. This damping is accomplished by mounting pieces of soft rubber tightly between the iron reed or diaphragm and the pole pieces. The photograph in Fig. 5 shows how this is done in the pick-up unit made by the Stromberg-Carlson Company. In the Amplion Revelaphone the entire vibrating iron reed is pivoted in sponge rubber. The reed is thus left free to vibrate between the pole pieces, but is damped by the rubber mounting at its pivot. The Bosch Recreator also operates on the damping principle of a rubber pivot rather than rubber between the pole pieces. The Baldwin Needlephone has a rubber damped pivot as well as damping rubber between the pole pieces.

MOUNTING AND VOLUME CONTROL

THERE are two main methods of mounting these electrical pick-up units on the phonograph turn-table. Most of them are built with their own mounting arm which holds the magnet and the needle on the record. The mounting arm is swiveled on a supporting base which screws on to the top board of the phonograph, adjacent to the revolving table. This is shown in Fig. 3, a picture of the Amplion Revelaphone. The Bosch arm is swiveled on a leaded base which is heavy enough to hold the arm in the correct position without screwing the base down to your phonograph. The Stromberg-Carlson unit has a leaded or weighted base, but has provision for screwing it down also, if desired. The second principle of holding the electrical magnet and needle on the record is that employed by the Baldwin Needlephone and the Pacent Phonovox. Both of these units are arranged for attachment on the present phonograph arm which holds the regular sound-box.

The regulation of volume of tone has brought forth almost as many ideas as there are different electrical pick-up units. In general, these volume control boxes are variable resistances which shunt out some of the electrical currents generated in the pick-up unit. An adjustable knob enables the volume to be reduced to an almost inaudible whisper. In the Pacent Phonovox and the Amplion Revelaphone these volume regulators are quite small and look more or less like an electric switch such as is often used in lamp cords. The Stromberg-Carlson control box is medium and is arranged for screwing on the baseboard of the phonograph, if desired. The control box for the Bosch is the largest of all, it being the largest piece of apparatus in the pick-up ensemble. Then, again, we have the other extreme in the Baldwin Needlephone, which has no volume control at all, but relies on the volume control in the radio receiver.

The question of weight on a record is indeed a serious problem. Records as well as needles wear out, and we are quite familiar with the fact that needles should be changed rather frequently.

FIG. 5. THE COMPONENTS OF A TYPICAL PICK-UP UNIT

However, one is not accustomed to think in terms of "record wearing." Nevertheless, this is quite an important factor, if the electrical pick-up unit is made at all heavy. It is this factor that has controlled the size of the magnet in the pick-up unit and accounts for the fact that all of them are extremely small. Of course, it would be possible to build a pick-up unit which would deliver considerable volume without amplification, but, the weight of the magnets would soon ruin any phonograph record. In this connection, it is

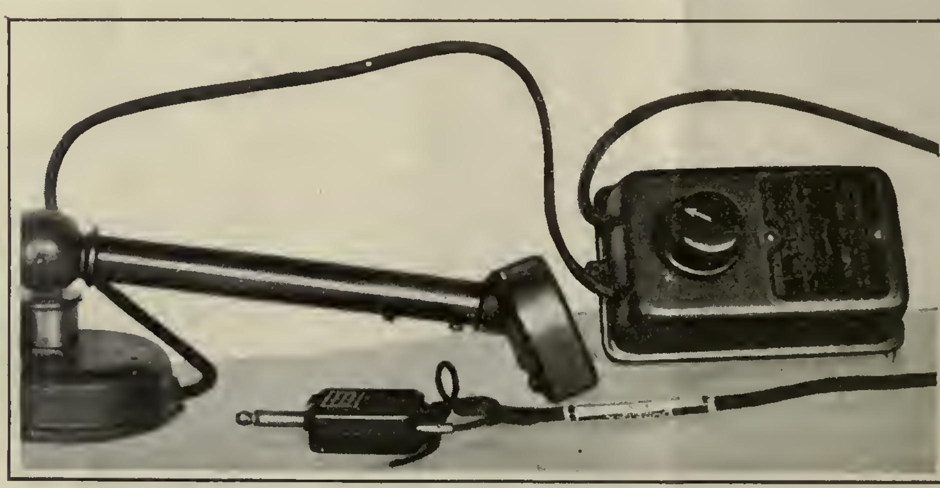


FIG. 5. THE STROMBERG-CARLSON PICK-UP UNIT

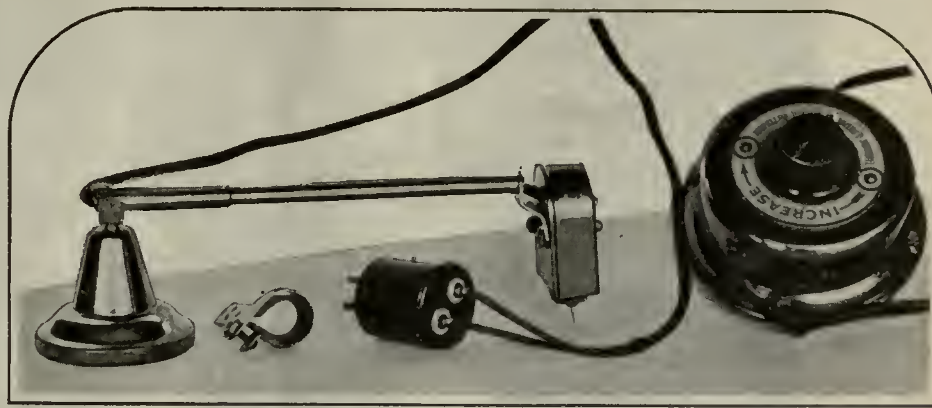


FIG. 6. THE BOSCH RECREATOR

worth while noting the Stromberg-Carlson system. A stiff rugged spring is mounted at the point of support for the pick-up arm and its mounting base. This spring tends to lift the arm and unit off the record. Of course, the weight of the unit overcomes the spring action, but the spring takes a great deal of the weight of the electrical pick-up unit off the record. The Amplion Revelaphone has a slightly different system. By making the unit arm pivot near the unit itself, only the weight of the unit rests on the record while the rest of the supporting arm is rigidly swiveled on the base, which is screwed to the top of the phonograph.

HOW THE UNITS ARE CONNECTED

THE methods of connecting the pick-up unit to the detector tube vary considerably in each case. The Bosch Recreator is attached by means of a special plug which fits into the detector socket in place of the detector tube. At the top of the plug are two tip jacks into which the cord tips are inserted. The Amplion Revelaphone is built with a combination plug and socket. The detector tube is removed, the plug inserted in the detector socket, and the detector tube replaced in the special socket at the top of the plug. The Stromberg-Carlson electrical pick-up unit is built with a standard plug which is made specially to fit into the proper jack for the purpose in their various models of radio receivers. The Pacent Phonovox Unit is designed with a very unique method of attachment which utilizes the amplification of the detector tube and so permits the tube to be reinserted in its socket. A thin bakelite strip with the proper holes is pushed on the pins at the base of the tube. The tube is then inserted into the socket. By means of eyelets in two of the holes (the grid and filament) contacts are made with two pin jacks at the outside edge of the bakelite strip. The electrical pick-up unit is connected by cord tips in these two pin jacks.

The electrical coils wound on the pick-up magnet must be very small, mainly because of the smallness of the pick-up magnets themselves. As previously discussed, the magnets must be as small and as light as is consistent with good results, in order to reduce the wear on the phonograph records. In order to make a compact, small, electrical coil, it is necessary to use very small wire. This wire is hardly larger than a hair, being in the neighborhood of No. 40 B & S gauge. Obviously, such a coil would quickly burn out if any battery currents were allowed to flow through it. Of course, any unit which is attached

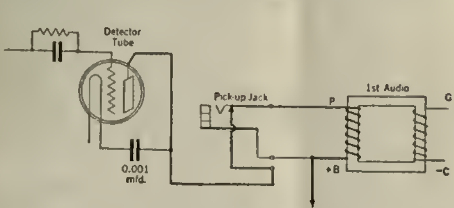


FIG. 8.

to the grid of the detector tube does not have to have any special precautions for eliminating the battery currents from the electric winding, as no battery current exists in this part of the circuit.

All of the pick-up units that are designed to operate on the plate circuit of the detector or the primary of the first audio transformer, must be

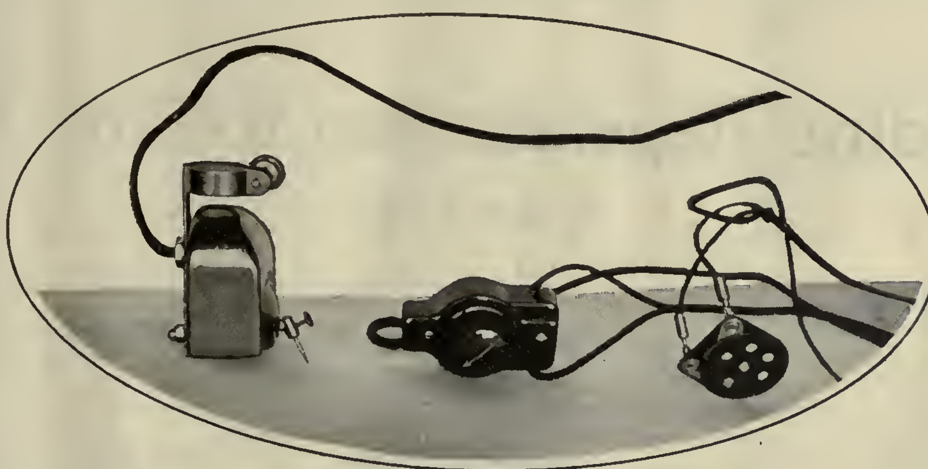


FIG. 7. THE PACENT PHONOVOX

arranged with a fairly large condenser in series. This condenser prevents the flow of the detector battery currents through the pick-up unit, but allows the audio current generated in the unit to pass through into the primary of the first audio transformer. This circuit arrangement is shown in Fig. 9. The Stromberg-Carlson receivers are equipped with a pick-up jack wired according to Fig. 8. This places the pick-up unit directly across the primary of the first audio transformer when the pick-up plug is inserted in the jack. A stopping condenser, under these circumstances, is not necessary.

HOW TO GET BEST RESULTS

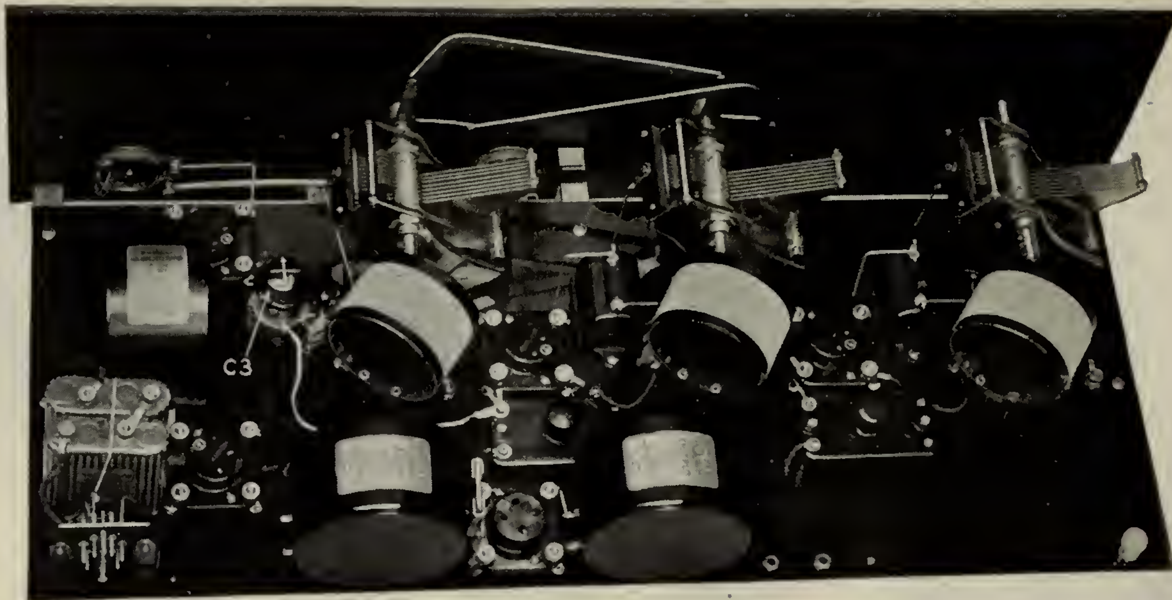
ALL of the electrical pick-up devices which we have tried operated very satisfactorily. Some were particularly low pitched while others covered the higher ranges. It would be entirely a matter of taste which would be considered the best from the point of view of tone quality. In this connection several important things should be mentioned in order to do justice to all types of electrical pick-up units. In the first place, it is most desirable to use the latest type of electrically recorded phonograph records. On the Victor records this can be easily ascertained by the letters "VE" at the top of the name-plate at the center of the record. This means "Victor Electric." Electrically cut records of other makes are also plainly marked on the signature of the disc. The old-fashioned records were not made with the bass notes because there was no way of reproducing these bass notes. You will not obtain the best tone quality on any electric pick-up with an old record.

In the second place, it is essential, for best results, to employ a power tube in the last audio stage of your radio set. Such a tube should be operated on at least 135 volts and should preferably be of the 171 type. This has more effect on the reproduction of the base notes than the audio transformers of your receiver. I have heard of a case where a man went to all the trouble of replacing his audio transformers in his radio set to give him the bass notes and then did not employ a power tube in the last audio stage.

In the third place, a good cone speaker, an exponential horn or a dynamic speaker should be used on the set. The use of the old type horns or small cone speakers will take away much of the excellent tone quality which is noticeable in the modern Orthophonic and Panatrope phonographs.

The most important of these suggestions is that you should have a power tube and good speaker if you are seriously interested in good quality. The reason for the excellent tone quality on the latest phonographs is not solely the electric sound-box. A loud speaker and a good power tube, such as is used in the Panatrope, are equally essential. The picture at the beginning of this article shows an excellent arrangement for phonograph reproduction. A Stromberg-Carlson pick-up, a Samson PAM power amplifier, and a Jenson dynamic speaker are used.

FIG. 9.



THE EQUAMATIC REVAMPED FOR REGENERATION

The Equamatic system is well known to all radio experimenters and home constructors. The addition of one small condenser, C_3, makes a lot of difference in the sensitivity of this circuit—as well as that of any neutrodyne or t. r. f. set

Adding Regeneration to Any Set

By Herbert Grove

> ### *Making Regeneration Simple*
>
> *MANY radio writers have a habit of making very simple things seem most complex. In this article, the originator of the Equamatic circuit, which was first described in this magazine, does the opposite. He tells how in a very simple fashion the seemingly complex trick of adding regeneration may be played upon the Equamatic, any t. r. f. set, or any neutrodyne. Such a trick should double the stations one can hear on a good night—at least, it did so in the Laboratory.*
>
> *Mr. King's trick consists in adding regeneration to the detector of the circuit by means of the primary of the r. f. transformer which connects the previous tube to the detector. The only additional instrument necessary is a small variable condenser. In some cases a r. f. choke may also be necessary.*
>
> —The Editor

ONE of the commonest ways of finding out whether or not a radio scheme works is the "cut and try" method. This is usually the longest way around an often simple problem, but radio has not yet advanced to the point where one can do all his labor at his desk or drawing board. Some work must be done with a screw driver, soldering iron, and pliers. A little judicious work with pencil and paper, however, will often save hours of labor and promise either ultimate disappointment or success.

For example, if you knew that adding a little regeneration to the detector of a neutrodyne, or t.r.f. set, or an Equamatic receiver, would give it sufficient pep to enable it to get that elusive dx, how would you perform this minor operation?

Before presenting a system for which we are indebted to Mr. Louis G. King, known to Radio Broadcast's readers as the originator of the Equamatic system, let us look at a few simple diagrams. In Fig. 1 we have the conventional detector circuit of a receiver—let us say a neutrodyne—in which an r.f. stage precedes the detector. This is the fundamental detector circuit used in such receivers as the Atwater Kent, the Crosley, t.r.f. sets, etc.

Following Professor Hazeltine's patent papers, No. 1,648,808, the primary P, will have about 8 turns, the secondary, S, about 60, and there will probably be a bypass condenser, C_1, from the plus 90 lead to one side of the filament circuit, as well as one across the audio input, C_2. Condenser, C_1 will be about 1 mfd., effectively conducting r.f. currents through the primary coil back to the filament of the last r.f. amplifier tube and keeping them from running all over the plate in the B-battery leads. Condenser C_2 is usually about .001 mfd. and is placed across the audio amplifier input so that r.f. currents in the plate circuit of the detector are given an easy path across the amplifier. A better way to connect C_2 is from the plate to the filament of this tube so that these r.f. currents need not go through the B battery or plate supply. Of course, there will be a tuning condenser and some other apparatus, but since we shall not need to discuss them further we shall dismiss them from the argument at once.

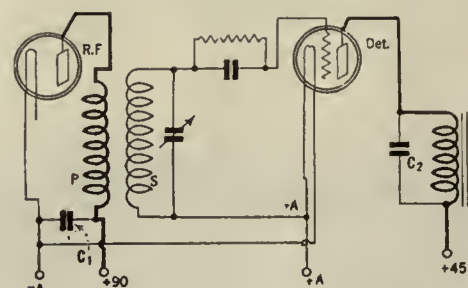


FIG. 1

The conventional detector circuit preceded by the primary of a transformer which couples this detector to a preceding radio-frequency amplifier

Let us revamp this diagram so that it looks like Fig. 2, which from the viewpoint of radio-frequency currents differs not at all from Fig. 1. Condenser C_1 connects the lower ends of both primary and secondary coils, and C_2 goes from plate to filament. Now let us look at Fig. 3, which is a simple regenerative detector. We have added coil T in series with the audio amplifier and the plate of the tube. All radio-frequency currents in the plate circuit of the detector must go through this coil before returning to the filament of the tube.

These changes are small, but the difference such a slight circuit change makes to weak signals is remarkable. Regeneration in a detector

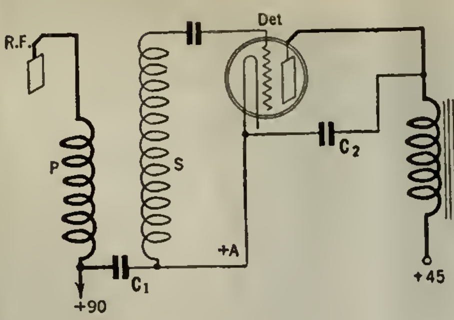


FIG. 2

The same detector circuit as shown in Fig. 1, but drawn differently. The bypass condenser, C_1, connects directly from the bottom of the primary to the filament and hence to the bottom of the secondary winding. Radio frequency currents are bypassed from the plate to the filament directly

is often as good for weak signals as two or more stages of radio-frequency amplification. How can we make our neutrodyne detector, Fig. 1, look like Fig. 3? Add a tickler coil? No, says Mr. King, there is a simpler way. Let us look at Fig. 4. This is exactly the same as Fig. 3 but drawn differently—the tickler coil is at the bottom of S instead of on top of it. It works just the same.

The next step, shown in Fig. 5, is more complicated. Here is where the trick begins.

In Fig. 5 we have added a radio-frequency choke and regeneration condenser, C_3, and placed the audio system as a shunt path, instead of a series arrangement, to the regeneration circuit composed of T, C_2 and C_3. The choke keeps the r.f. currents out of the audio system; C_3, which is about 0.0001 mfd. keeps the audio currents out of the tickler circuit. We have provided an effective filter system, keeping the two frequencies in their respective channels. The tickler coil, T, is now fixed in place and regeneration secured by varying C_3.

THE R. F. PRIMARY AS A TICKLER

HERE is where Mr. King steps in. He notices that the primary coil, P, is attached to the secondary by C_1, just as tickler T is, and says why not use P as the tickler coil as well as the primary of the r. f. transformer which connects the r. f. amplifier to the detector? The result is Fig. 6.

If applied to a neutrodyne or t. r. f. set of the conventional type it will be necessary to adjust the regeneration condenser at each frequency, since more regeneration is needed at the longer waves. But if applied to an Equamatic, and Mr. King had this receiver in mind when he worked out the trick, C_3 can be placed inside the cabinet, adjusted, and let alone. The photograph at that head of the article gives a good view of the installation. It can be fixed so that the detector oscillates all the time, or nearly oscillates, or so that the additional pep is just enough to give one the dx required. This simplicity is due to the variable coupling between P and S, which is the heart of the Equamatic system and which automatically increases the coupling between T and S at the longer waves where more coupling and more regeneration are needed.

Sometimes if the impedance of the audio frequency channel is sufficient at radio frequencies to keep r.f. currents from flowing through the winding and to force them through the shunt circuit, the choke may be omitted. It will be necessary to remove the condenser across the audio input, and if the regeneration condenser, which may be 0.0001 mfd. as a starter, is not sufficient to cause oscillations at the longest wavelength to be received, the choke may be added.

Suppose, then, we have an old-style neutrodyne. We get into the box, attach our regeneration condenser from the plate of the detector to the plate of the previous r.f. tube, and listen-in. If nothing happens we look for the bypass condenser across the audio transformer primary and remove it. The detector should now oscillate at the shorter wavelengths and with about 0.0001 mfd. regeneration capacity. If the detector does not oscillate, the primary of the transformer, which is also being used as a tickler coil, must be reversed. If the detector oscillates on the longer waves as well as on the short, all well and good. The next step depends upon the type of set to which this trick is being applied. If it is an Equamatic receiver, in which the primary automatically moves as the tuning condenser capacity changes, nothing need be done but to determine the best setting for the regeneration condenser. This is the point at which regneration occurs at all wavelengths, but actual oscillations do not occur at any. Some receivers have decided bumps and hollows in the gain-frequency curve, so that a setting of the regeneration condenser which does not cause the detector to break into oscillation at one frequency will cause decided oscillations at another. The trick is to find the position of this condenser which causes oscillation at no setting of the tuning dials.

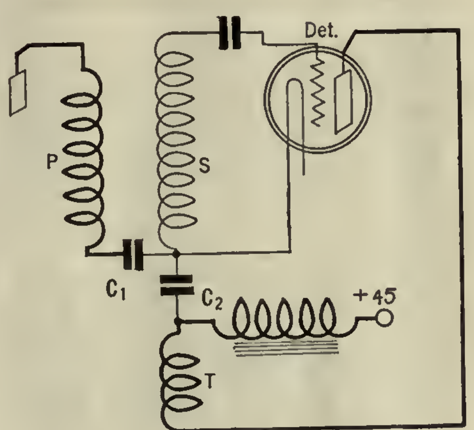


FIG. 4

The same regenerative detector drawn differently. The tickler coil is at the filament end of the secondary instead of near the grid end It works equally well in the two cases

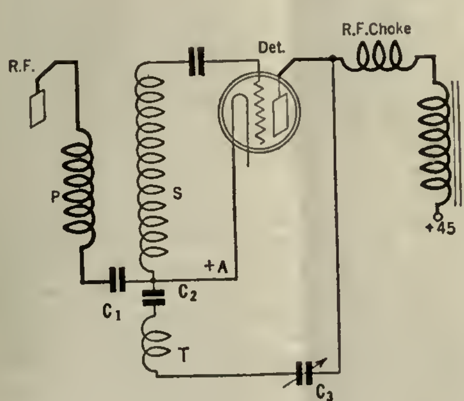


FIG. 5

Instead of a series tickler and audio system arrangement, we can use this arrangement, which shunts the audio input across the regenerative apparatus. Variable regeneration is obtained by the condenser, C_3

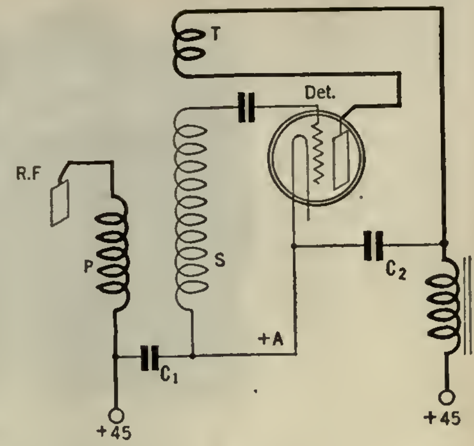


FIG. 3

A rengerative detector. The additional coil marked T is the tickler. There is no more sensitive or efficient single circuit than this

If the receiver has fixed primaries, as in the neutrodyne or the t.r.f. sets, the regeneration condenser had better be on the panel so that the amount of regeneration is under control at all times. With such an additional control it is always possible to make the detector circuit oscillate, and to tune in stations by the familiar "squeal" method. If oscillations do not occur in the longer wavelengths, the choke will be necessary.

In the latest Equamatic, in which a stabilizing condenser is used as shown in the photograph at the head of the article, the procedure is as follows. Open up the stabilizing condensers until the receiver oscillates. Then screw them down slowly until the set is under control at all frequencies. Then add the regeneration condenser, and choke, if necessary, and ascertain the combination of stabilizing capacity and regeneration capacity that is best—it must be determined by experiment alone.

The result of such a procedure is to make the receiver, be it an old-style t.r.f. set that has little or no amplification at the lower radio frequencies, or a modern high-gain set, more sensitive and naturally more selective.

The parts necessary for these changes are but two, the 0.0001 mfd. variable condenser and the r.f. choke—which may not be necessary.

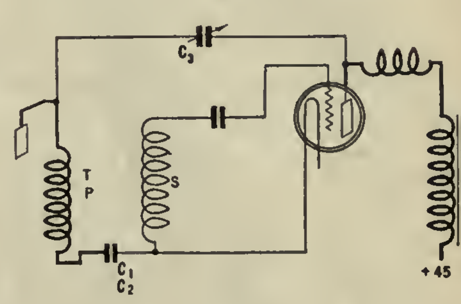


FIG. 6

Instead of adding a tickler, we may use the primary of the interstage transformer, not only as a primary, but as a tickler as well. The r. f. choke may not be necessary, provided the condenser across the audio primary is removed. Condenser C_3 provides the variable regeneration necessary to cover all frequencies

THE PANEL OF THE 5-METER RECEIVER
A top view of this receiver is shown in Fig 1. At the left is the tuning condenser, of the vernier driven type. The knob in the center of the panel is the regeneration control. At the right is the filament rheostat

What About the 5-Meter Band?

By R. S. Kruse

MANY years ago, when there was no radio but telegraphic radio, we used to talk to station 9LQ, at Lawrence Kansas. Not so many years ago we met the operator of this station, who was then at Cruft Laboratory working with John Hays Hammond on the various secret radio transmission systems in which the inventor was interested. Together we listened with considerable awe to lectures on tubes, etc., from Professors Pierce and Chaffee. Since then, we have known Kruse intimately through his breezy articles in QST.

Now, we are glad to say that Mr. Kruse will be a regular contributor to Radio Broadcast. *He will speak about short-wave receivers, transmitters, antenna systems, laws, problems—and all that goes with them. An article to follow this one will give the constructional data on the 5-meter receivers and transmitters described in this article. If there is any reader of* Radio Broadcast *who does not know Kruse already, he is hereby introduced!*

—The Editor.

THERE has been too much sorrowing for the Ishmaelites, those chaps who fell out with the community and took to the hills where there were better chances of running away—and more things to run from. I suspect that in the course of hunting and being hunted they fell across more interesting things per month than their orderly relatives down in the towns saw during a lifetime.

This is of course an argument for crime and disorder, which is quite fitting, since we are about to tell a story of some wholly irregular proceedings that resulted in driving a surprising lot of interesting radio rabbits out of the electric brush.

HOW IT BEGAN

OF COURSE there isn't anything novel about the 5-meter wave except by reason of its having so long lain in mothballs with all the other short waves that the early radio men from Hertz to Marconi investigated. The spark apparatus then available not being very suitable for short-wave work, not a great deal was learned, and the styles turned toward long waves with antennas large enough to cover a Texas county.

When the vacuum tube had become thoroughly practical as a transmitting device we were treated to the singular show of a world full of radio folks stoutly insisting that a vacuum tube was useless on all waves below 400 meters— but that it was of small moment, since the waves below 350 were worthless anyway.

At this statement a number of us went off the reservation just as the Indians used to and after some bushwhacking around we discovered that the short waves were not worthless but looked astonishingly as if they might be improvements on the longer waves. Furthermore, we found that the vacuum tube oscillated nimbly at 60 meters, whereas our spark sets refused to get down to 150 at all. This was duly denounced as rank heresy by the orthodox, who took no part whatever in such practices, i.e., making circuits that would oscillate at 60 meters.

So it went, even as late as 1921. Sprinklings of stations below 200 there were, but at least one of us (which was I) was hauled before the radio club and accused of communicating with an imaginary station because I and the station I was working were both on 160 meters, and the accuser, being nearby, could hear my part of the proceedings but not the other fellow. Of the commercial folks our good friend Grebe first showed faith by building a tuned r.f. amplifier that went down to 150 meters!

Grebe shows his continued faith in short waves by continuing to build receivers for the very high frequencies.

By 1923 we had become fed up with this sort of thing, and through the machinations of Boyd Phelps and myself, some amateur stations staged an "Exploring 100 Meters" Party, moving our transmitters down by steps and demonstrating that signals would really come through at such wavelengths as 60 meters. There was loud derision at first—and puzzled silence afterward—for the signals had of course come through like the well-known ton of bricks just as several years of tinkering had assured us they would. The tinkering was, by the way, started by Phelps at least as early as 1919 with a low-power 33-meter spark set. After that many names appear that all amateurs know—Reinartz, Dunmore, Conrad, Ramsay. Presently, there was a short-wave "CQ Party" and many stations were heard over great distances. However, the great congregation remained at the old waves—mainly a little above 200 meters. It is very singular that all the wavemeter errors were upward!

Presently, the Washington Radio club produced some active 100-meter stations, those of Browne, Darne, Basim and Hastings in particular. Soon we managed to blast out of the authors some articles on short-wave tuners. These tuned all the way down to 90 meters and Schnell's went to 60 even.

Things now became active—there were investigations between the Naval Research Laboratory and other stations, under the leadership of Dr. A. H. Taylor and L. C. Young. Then a coöperative arrangement with Leon Deloy of Nice, France, put our own Schnell's 100-meter signal across the Atlantic and then Deloy's came back. A few hours later Reinartz talked to Deloy and then many others did it. Presently in 1924, the Department of Commerce gave back again to the amateurs some of the territory below 150 meters, which resulted in the present system of amateur wavebands and the pages of *QST* bristling with articles on using them. The population, however, howled murder and refused utterly to use the low waves until there was much more demonstration by Schnell and others that the 40- and 80-meter bands were good ones. At that the 20-meter band lay idle until the Experimenter's Section of the American Radio Relay League made 20-meter tests resulting in daylight transcontinental contact between Reinartz on the East Coast and Willis on the Pacific.

SETTLING UP

BY THIS time the 80-meter band was settled territory and presently the 40-meter band became the same. Nowadays, the 20-meter band is thickly populated. Long ago, however, the ones who discovered the 20, 40, and 80-meter bands have moved on down to 5 meters and have run assorted tests with uniform results—oh, very uniform! Without exception there have been no signals but those of Uncle Henry's model T ignition systems. From this it is clear that there is nothing to this 5-meter business, especially since the latest and most up-to-date transmission theory points out clearly that wavelengths of the order of 5 meters will never come

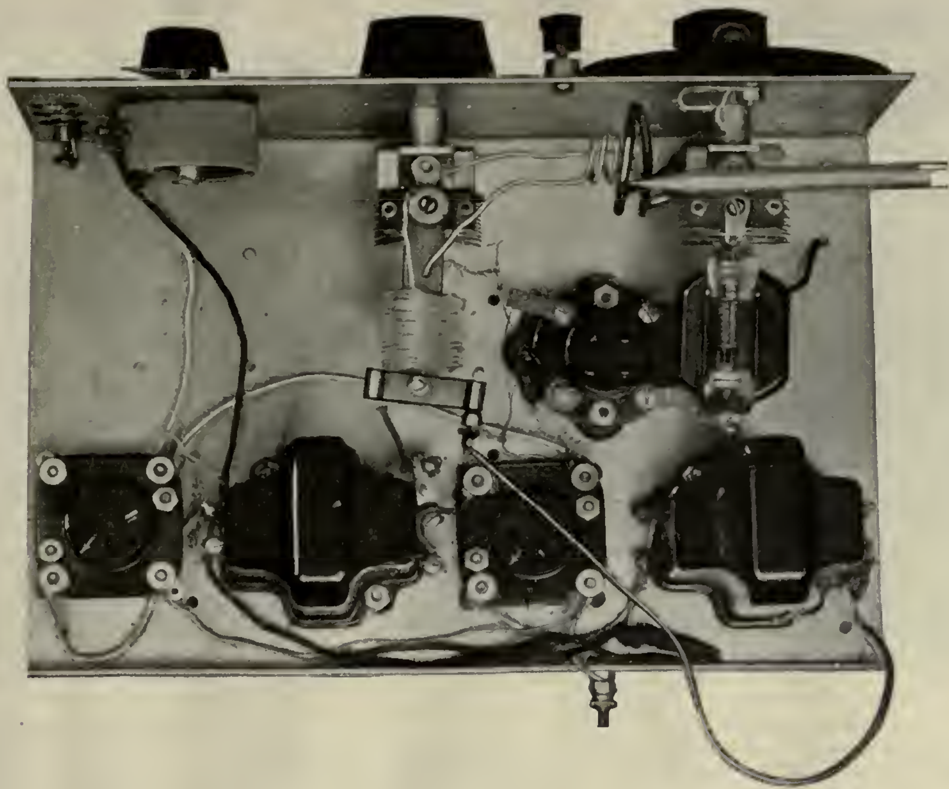


FIG. 1. A RECEIVER THAT GETS 5 METERS

An ancient 5-meter receiver—still good. This set was used to make 1200 field observations on transmissions from 2EB at Jamaica and 1OA at Hartford and Glastonbury. The circuit is perfectly normal, being of the general type of the circuit shown in Fig. 2 plus a second audio stage. With so simple equipment the signals from a UX-852 have been copied in a moving car through ignition noises at 5 miles, and at 60 miles with the car stationary and a 20-foot antenna hung on a tree. The pencil points toward the tuning inductance

down at all on this earth, except, mayhap, in the antipodes.

However, the wanderlust drives on the same group that originally departed from the 200-meter reservation. With the group consisting of Ducati of Italian, 'ACD,' Douglas out in Kansas, Phelps and Kruse on the east coast, it became necessary to make some more detailed study in place of mere "blind" transmissions.

EXPLORING 5 METERS

AT THIS point there entered the radio flivver, financed by Phelps and known as *Conny* because of its Connecticut and New York licenses. The flivver wandered restlessly about Jamaica and Hartford, gradually determining what one may expect 5-meter waves to do. The results were surprisingly normal and unalarming. The signals do not die off in the rapid manner that we had been warned against, nor do they do anything especially freakish.

Some 14 months prior to the days of *Conny* a few signals from an ancient 5-watt UV-202 transmitter of Phelps, at Staten Island, had managed to put signals at 5.2 meters into Glastonbury, Connecticut, where an amazing "haywire" receiver of mine received them. We hoped to repeat this and make it more consistent. We did repeat it, but not before many trials were made, more power used, the apparatus repeatedly improved, and an appalling number of tests run. Our difficulty was with a tremendous "noise level," far worse than at longer waves. This having finally been greatly reduced by means of a double detection receiver, we again hoped for communication, but failed.

Phelps then built a huge automatic key that ground out his call and a test signal by the week; and after some listening this was heard in Kansas by Douglas and in Seattle by another listener. My own signals struggled as far as Kansas, and I heard Ducati's signals. Ducati's transmitter was located at Bologna, Italy, and used about 400 watts. This began to look more hopeful but the contacts were always brief. Phelps then organized a two-way contact with E. S. Strout, 2NZ, of Newark, N. J., and several conversations were held at 25 mile distance. However, the "lure of distance" was again at work.

MORE DISTANT RECEPTION

IN THE fall of 1927 a trip to the West Coast seemed to offer a good opportunity. A 5-meter double-detection receiver was rather hastily discarded in favor of a new detector-audio receiver which I took to Lawrence, Kansas. However, it proved to be not sensitive enough and was replaced by another and better double-

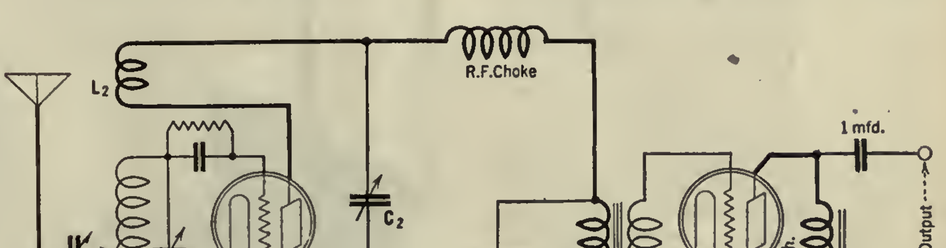


FIG. 2. A SIMPLE 5-METER RECEIVER CIRCUIT

This receiver is of the detector-audio type. Regeneration control is by the resistor, R, only the Frost type having proved satisfactory at 5 meters. The UX-112 and 112A detector tubes are best. C1, C2, and C3 all have the same capacity, about 10 mmfds., obtained by trimming down a "vernier" condenser. L1 may range from 1 to 4 turns of about 1" diameter. C1 must be driven by a quiet vernier dial, such as National type F, while C3 needs only a knob for "set and forget" use—otherwise the tuning will be all mixed up since the use of this condenser disturbs calibration. C4 should have a capacity of not over 0.0001 mfd. The grid condenser is about 100 mmfds. with a high leak (8 megs). The detector tube must be cushioned on sponge rubber and all leads to it made flexible.

A WAVEMETER—OLD STYLE

A bit of history. This old time wavemeter was used by Phelps at 9ZT in Minneapolis in the fall of 1921. The range is from 10 to 150 meters, (a range of 28,000 kc.) and the condenser has a capacity of 1000 mmfds.

detection set built before breakfast in some miraculous way by Douglas. With this nothing was heard at Newton—180 miles west—at night, which was expected. At Grand Canyon, Arizona, both Norwell Douglas (Kansas) and Phelps (New York) were very weak. At San Diego, neither were the signals thrillingly loud nor were they amazingly steady, but they were *there!* At San Antonio, in the midst of perfect receiving conditions, there was an equally perfect silence. As nearly as can be established, the reflector at 9EHT (the Kansas station) was not aimed right, and the schedule at 2EB (the New York station) was either not sent or else sent at another time than it was listened for. At New Orleans the set stubbornly refused to function and after finally being persuaded into unstable oscillation, grudgingly turned out a rather weak and barely readable signal from Kansas.

All this looked highly encouraging, especially when viewed in the light of the reception of Italian 1ER (Santangeli)—a distance of about 1000 miles—at Tripolitania by Captain Filipini, and the rather consistent 24 mile reception by C. H. West (2CSM) of his own very low-powered automatic signals at distances within 24 miles of Stapleton, New York, and finally the very nice work of C. H. Turner with a crystal-controlled 5-meter transmitter in the Vermont mountains at distances above 100 miles.

The thing was especially interesting because the results did not "gee" very well. Turner's conclusions were that the wave was a daylight one (on which we seem to agree) and that it was useful only for straight-line work, whereas we have numerous cases wherein the signals were very healthy indeed behind hills of good size, for instance, on the opposite side of Avon "mountain" (Connecticut for hill) from my own Hartford station. Again the alleged daylight wave has at certain times shown a strange disposition toward abnormally strong signals on very foggy days, though this applies seemingly to the "local" (60 miles or less) signal only. In the main, the distance reception has been best and steadiest with clear skies, the California "high fog" (West Coast for generally cloudy) being a good barrier in the few cases where it was possible to observe while it parted.

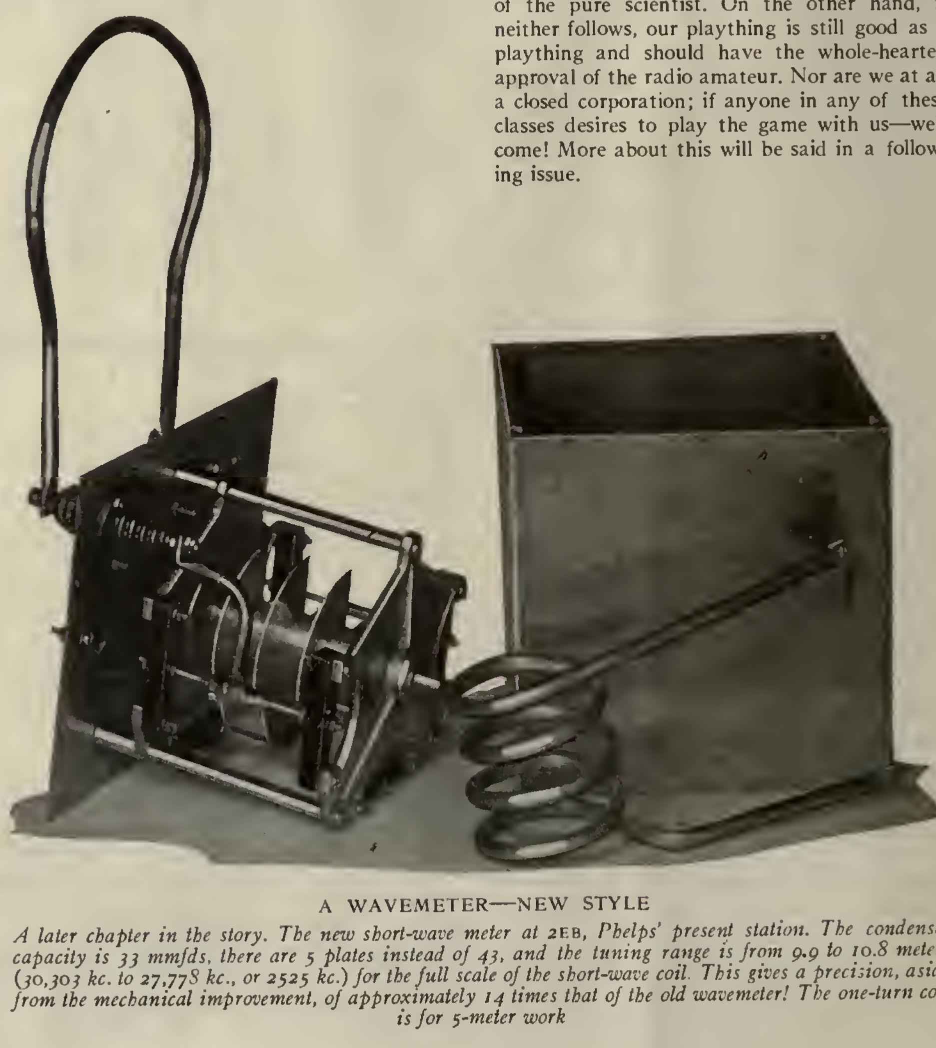
Again, the attenuation (i.e., the dying off of the signal as one goes from the station) does not seem to follow theory. The thing seems to fall off no worse than some other wavelengths which are, theoretically speaking, better.

THE ABSENT ANTIPODES

IT IS, perhaps, especially interesting that the Australian observers, who seem to be better than average, have never heard the signals. They are the ones with the best mathematical right to hear signals—which again leaves matters open for speculation.

For that matter there is no end of room for speculation in the whole thing. A few of the puzzling things we hope to answer. Douglas has a pair of reflectors, horizontal and vertical, with which to aim signals at suspected points, and Langreth of Wesleyan University, at Middletown, Connecticut, is building a crystal-controlled 5-meter transmitter to wash out some of the other uncertainties. To fit into this picture there is being made a receiver with CX-322 intermediate-frequency amplification, a long-wave heterodyne and an autodyne first detector, all of which is hoped to be an improvement on present equipment. Perhaps there will be something more to report of communication results.

Meanwhile, the reader, if still following this story, has begun to do a bit of speculating of his own, asking of what conceivable use all this may be. As to that—why is that so serious? If we make a "useful" wave of 5 meters then the utilitarians will say the thing has been good all along. And if by any rare chance an interesting scientific fact emerges we have the approval of the pure scientist. On the other hand, if neither follows, our plaything is still good as a plaything and should have the whole-hearted approval of the radio amateur. Nor are we at all a closed corporation; if anyone in any of these classes desires to play the game with us—welcome! More about this will be said in a following issue.



A WAVEMETER—NEW STYLE

A later chapter in the story. The new short-wave meter at 2EB, Phelps' present station. The condenser capacity is 33 mmfds, there are 5 plates instead of 43, and the tuning range is from 9.9 to 10.8 meters (30,303 kc. to 27,778 kc., or 2525 kc.) for the full scale of the short-wave coil. This gives a precision, aside from the mechanical improvement, of approximately 14 times that of the old wavemeter! The one-turn coil is for 5-meter work

"Our Readers Suggest—"

Increasing the Output Voltage of B-power Units

IN PAST numbers of this department suggestions have been offered by readers for the modernization of power supply devices designed before the advent of high-voltage rectifying tubes and power tubes. These suggestions have generally considered the possibilities of improved voltage divider systems, the addition of C-supply resistors and the slight gain effected by the use of new rectifying tubes. Two readers of this department, William C. Millar of Long Island City, N. Y., and Wallace Allen of Denver, Colorado, have simultaneously contributed details of a simple device that, connected exterior to the power supply unit, increases the output voltage of the transformer, making it possible to take full advantage of the new tubes and voltage distribution system. Both contributors have suggested the same arrangement, but, as they individually cover slightly different phases of its possibilities, the editor has combined their two contributions into a single article, rather than accepting only one of them.

The device recommended has two principal advantages. It permits the use of C bias resistors in the negative plate current return without reducing the applied plate voltage below the potentials secured without the bias resistors and the booster. Also, it raises the output of power-packs designed for the original Raytheon and similar tubes to voltages suitable for the efficient operation of modern power tubes.

The arrangement, fundamentally, is a transformer booster, raising the line voltage from approximately 115 volts to 130 volts before applying it to the input of the power supply transformer. The output of the power supply source is increased in proportion. The filter systems of present-day line power devices built by reputable manufacturers have a factor of safety permitting this overload. This is not generally true of units designed several years ago and there is a possibility that filter condensers will break down if this method of increasing the output voltage is applied to some older B-power units.

The only additional part required is a small toy or bell ringing transformer having a secondary output of about fifteen volts. This is connected between the line and the power supply unit in accordance with the diagram, Fig. 1.

The secondary of the step down transformer is connected in series with the primary or line voltage, giving an additive effect when connected properly. (If the output voltage of the power unit is less when the booster is used, the connections to the secondary should be reversed.) So connected, the device is, in effect and actually, an auto-transformer.

A new BH Raytheon tube (or similarly perfected rectifying tube) should be substituted for the type employed with the lower voltage in order to take full advantage of the increase.

Mr. Millar suggests that this arrangement might well be employed even with modern power supply units to compensate poor line regulation in suburban districts. In this case a tapped boosting transformer such as the Ives type 204 and the Thordarson TY121 will provide the desired regulation.

OUR Readers Suggest" is a clearing house for short radio articles. There are many interesting ideas germane to the science of radio transmission and reception that can be made clear in a concise exposition, and it is to these abbreviated notes that this department is dedicated. While many of these contributions are from the pens of professional writers and engineers, we particularly solicit short manuscripts from the average reader describing the various "kinks," radio short cuts, and economies that he necessarily runs across from time to time. A glance over this "Our Readers Suggest" will indicate the material that is acceptable.

Possible ways of improving commercial apparatus is of interest to all readers, The application of the baffle board to cone loud speakers, is a good example of this sort of article. Economy "kinks," such as the spark-plug lightning arrester, are most acceptable. And the Editor will always be glad to receive material designed to interest the experimental fan.

Photographs are especially desirable and will be paid for. Material accepted will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas.

—THE EDITOR.

Cleaning Corroded Battery Terminals

ASIDE from being unsightly and causing general corrosion of A-battery leads, dirty terminals on a storage battery are responsible for much of the so-called "static" experienced in many receivers. Dirty terminals are easily cleaned by washing with a saturated solution of baking (bicarbonate) or washing soda. The terminals should be swabbed with this solution until there is no more effervescence. The terminals and battery top may then be wiped perfectly clean with a rag.

In addition to cleaning the battery, the soda wash effectively puts a stop to the corrosive action by neutralizing the acid—an effect that cannot be secured by ordinary cleaning.

A. J. PETERS, San Francisco, Cal.

New Use for a Block Filter Condenser

THE more popular models of dynamic cone loud speakers, such as the Jensen or Magnavox, require a six volt source of magnetization current. I find that this can be adequately supplied by many of the popular trickle chargers with a Tobe A Block connected across its output to eliminate hum. This combination is altogether satisfactory, not a trace of a.c. being perceptible in the speaker, which functions at full efficiency.

ALBERT E. CHASE, Quebec, Canada.

Simplified Plate Rectification

THE advantage of plate rectification—the lessened possibility of introducing distortion through overload of the detector tube—has been described on various occasions in "Our Readers Suggest" columns. In some cases this advantage fails to justify the loss in detecting efficiency. It would be well to determine, before permanently changing the wiring in the receiver, whether or not satisfactory signal strength will be obtained on the desired stations when using plate rectification. This can be found out in a half minute by substituting a C battery for the grid leak in the average receiver. The C battery is connected across the grid leak mounting. It is not necessary to remove the grid leak. The negative side of the C battery is connected to the grid side of the leak. The potential should be varied between 1.5 and 9.0 volts, the plate voltage being changed from 22.5 to 60.0 volts for each C battery adjustment, in an endeavor to determine a combination giving the greatest signal response.

HENRY WHITEHALL, Camden, N.J.

Parallel Plate Feed

THE use of a parallel feed, i.e., a separation of the direct current and alternating current paths in the plate circuit of a vacuum tube, certainly has no claim to novelty. This system of connection has not, however, achieved the popularity to which its merit would seem to entitle it. So far the set builder is familiar with the circuit only as associated with the loud speaker, where the use of the so-called "speaker filter" has become general. The parallel plate circuit applies the principle of the speaker filter to the audio amplifier. The circuit is illustrated in the diagram in Fig. 2.

Inductance L should have a high value of about 100 henries. It must be of such construction as to maintain its inductance at currents of several milliamperes. Capacitor C is a condenser of sufficiently large capacity to offer a low impedance at low frequencies—from 2 to 4

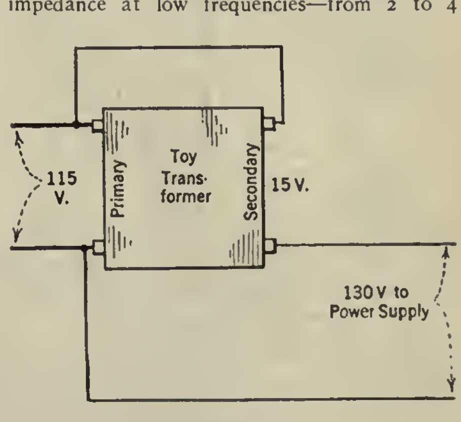


FIG. 1

A simple and inexpensive booster arrangement which will increase the output of a power supply device from ten to fifteen per cent.

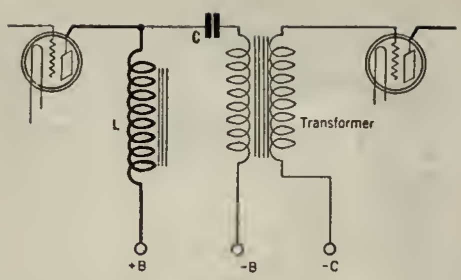


FIG. 2

The principle of parallel feed, familiar in output devices, applied to the conventional transformer-coupled amplifier.

microfarads. The direct plate current flows through the choke, L, which has a low impedance to direct current, while the condenser offers an effectual bar to the flow of direct current through the primary of the transformer. Alternating current is prevented from flowing through the choke, L, in appreciable amount because of its high impedance, while the condenser and transformer primary offer a path of low impedance as compared with that offered by the choke. In this way the two components of current existing in the plate circuit of the tube, i.e., the space current (constant and undirectional), and the audio frequency signal current are directed into different circuits.

The separation of the direct and alternating components of the plate current of a vacuum tube is desirable for a number of reasons. Direct current flowing through the primary of a transformer sets up a field in the core which may cause magnetic saturation in the core. Saturation is a condition under which changes in magnetizing current do not produce corresponding changes in flux. Since the operation of the transformer is dependent on changes in flux, the instrument is naturally affected. The better the transformer, the more likely is this to happen. If the transformer's core is of silicon steel, saturation is not likely to occur with tubes of the 201A or 199 type, but if a 112 or 227 tube is used, saturation may occur. Cores of nickel steel such as are coming to be used to an increasing extent are much more subject to this difficulty than are silicon cores.

Many experimental receivers employ semi-power tubes, such as the 112, in the first stage. In such cases, the following transformer should always be parallel fed.

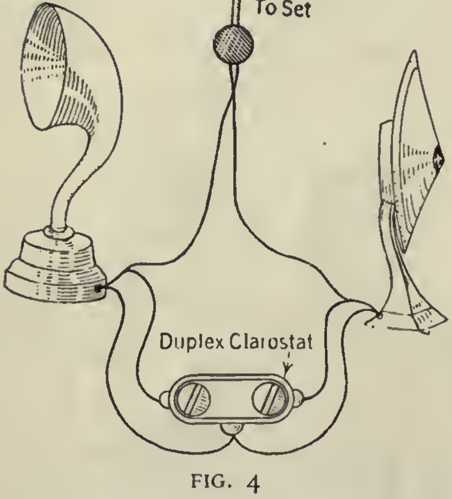


FIG. 4

This balancing arrangement for adjusting cone and horn speakers connected in series is useful where one unit favors the high frequencies and the other low frequencies.

Currents of more than a few milliamperes will seriously affect the behavior of the nickel steel transformer, and the instrument may easily be permanently injured by the application of too large a direct current magnetizing force. The effect of saturation of the iron is to reduce the input impedance of the instrument, resulting in a loss of amplification which is particularly marked at low frequencies. When using cores of some of the nickel alloys, the gain due to the special core material may be completely sacrificed as a result of too much direct current in the primary.

The elimination of oscillation and motor-boating in the amplifier is another advantage gained by the use of parallel feed. It has been noted that the signal current does not flow through the direct current circuit, i.e., no signal or audio-frequency current flows through the plate supply unit. Since no signal current from any stage flows through the plate supply, no audio-frequency voltages are set up, and no coupling between the stages results from the common impedance in the plate supply device. The result is an increase in the stability of the amplifier, and elimination of regeneration and "motor-boating."

C. T. Burke, Cambridge, Mass.

Some More on Balanced Speakers

"OUR Readers Suggest" has devoted considerable space to the interesting possibilities of operating speakers of opposing characteristics, such as a cone and a horn, in series in order to obtain adequate reproduction of both high and low notes. Different resistor devices have been suggested to determine the correct balance. I find that the simple arrangement, employing a Duplex Clarostat, as shown in Fig. 4, altogether satisfactory and less complicated than the systems heretofore suggested. I am using an R.C.A. horn with a Western Electric 24-inch cone. When the right hand screw is tightened, the cone is cut out of the circuit and the high notes emphasized. When the left hand adjusting screw is tightened (and the right hand screw loosened if necessary) reversed conditions prevail, and the low notes are accentuated. Once the correct balance is obtained, the resistors should never be touched, and the screw driver adjustment is well adapted to this semi-permanence.

R. Mackey, Schoharie, N.Y.

A Milliampere Meter Protector and Multiplier

A FEW days ago the representative of a well-known manufacturer gave me a startling figure on the number of milliammeters repaired daily at his factory. After one of mine had been laid up for repairs, I adopted the protective device shown in Fig. 5.

The milliammeter is shunted with a 30-ohm General Radio filament rheostat. When the ammeter is inserted in the circuit, the resistance is adjusted so that the resistance is practically cut out. In this position, a very slight deflection of the meter is noticeable, which serves to show if the polarity connection is correct. The resistance of the rheostat may then be gradually increased and the meter reading noted. If the current in the circuit is above the meter capacity, it will be noted before any damage is done. Providing all is well, the rheostat may be turned to the "off" position, which gives normal full deflection on the meter. If the meter has a scale of fifty or more milliamperes, the rheostat may be used as a multiplier with sufficient accuracy for all ordinary purposes.

While on the subject of protection, I might

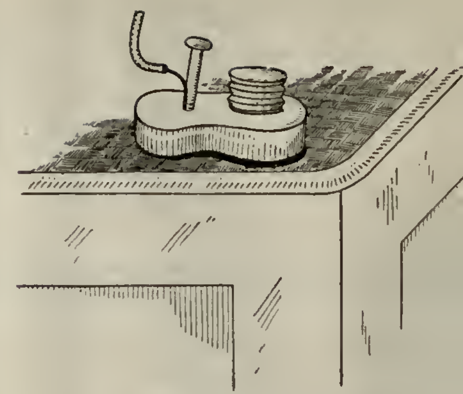


FIG. 3

An emergency storage battery connector that i[s] quite independent of the elusive binding-post cap[s]

add that I find the 199 Amperites a very effectiv[e] fuse in the B and C battery circuits, and 1- and 3-ampere fuses useful in the A circuit.

Edward T. Werden, Mt. Vernon, N. Y.

STAFF COMMENT

THE rheostat can be used as a multiplie[r] regardless of the range of the meter as fa[r] as the requirements of the average experimente[r] are concerned. The rheostat should be set s[o] that the indication of the meter is some easily multiplied fraction of the actual current. Fo[r] instance, with the rheostat open, the curren[t] through the meter should be noted (any desired current can be secured by connecting the mete[r] in series with a high range Clarostat and a dry cell). The rheostat is then cut in until the cur[-] rent through the meter drops to one half or one third or one tenth of the original reading. Thi[s] fraction will then hold for all readings. Fo[r] example, if the rheostat is set for a one quarte[r] deflection, three milliamperes on the meter in[-] dicate an actual current of twelve milliamperes.

Tinning Wires

WHEN using an untinned wire for the in[-] ternal connections of a receiver diffi[-] culty is often experienced in tinning the end[s] before making a joint. The process of tinning these wires may be carried out much mor[e] effectively if a groove is filed in one of the surface[s] of the soldering iron. This groove will readily fil[l] up with solder, and then by sliding the wire to b[e] tinned into the groove, it will be tinned on al[l] sides simultaneously.

J. B. Bayley, Jersey City, N. J.

Emergency Battery Connections

IN THE absence of the usual battery clip [a] good emergency connection may be made with an ordinary one inch finishing nail, or even a fla[t] head if it is of small diameter. First drive th[e] nail into the lead end post about a quarte[r] to three eighths of an inch. This may seem difficult, but is really very easily accomplished. Then remove the nail and insert the wire from th[e] receiver or charger and drive the nail in again. Fig. 3 shows how it is done. This will mak[e] a good solid contact equal to the carrying capacity of the wire used.

J. B. Bayley,
Jersey City, N.J.

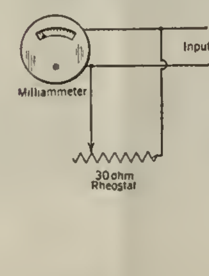


FIG. 5

An inexpensive milliam[-] meter protector and multi[-] plier that will save its fifty cent cost many times over

A NEW WAY TO RECLAIM OLD SETS

The use of the screen-grid tube in an external amplifier unit constitutes one of the simplest and most efficient ways of giving new life to receivers that are in need of a little more r. f. amplification. High gain, easy operation, and the elimination of the necessity for neutralization are among the features of this unit

An Extra R. F. Stage for Any Receiver

By The Laboratory Staff

THERE is hardly any receiver that cannot profitably utilize a little more radio-frequency amplification to enable its owner to reach out for those stations which ordinarily are just beyond the set's range. If, at the same time, selectivity can be added—and all this very cheaply—it is small wonder if many thousands of the one-stage screen-grid tube radio-frequency amplifiers described here are not built. It may be added in front of practically any receiver, and with those which are none too selective or sensitive now, the difference made on weak signals after they have passed through this amplifier is extraordinary.

Such an amplifier as is illustrated in Fig. 1 is quite simple to build. It adds a stage of radio, adds selectivity, adds dx-getting ability, and with simple sets like the one tubers, the crystal receivers, or the reflex receivers, makes all the difference between a local or one-station receiver and a high gain modern receiver.

The apparatus is as follows: a screen-grid tube, a coil and a condenser with a dial, a socket, an r. f. choke and a coupling condenser. The tube requires 3.3 volts at 0.132 amperes for the filament, 45 volts for the screen grid and from 90 to 135 for the plate. The bias on the control or signal grid is obtained by taking the drop across a resistance in the negative filament lead of the tube. The circuit diagram is given in Fig. 2, and any one can put the apparatus together in about an hour with the certainty that it will work. If desired a box can be built around it, or the whole outfit can be placed in an aluminum or copper can or—as was done in the Laboratory—it can be built in the simple manner shown in Fig. 1.

When this amplifier is used with a receiver which is not shielded, and which may already have considerable r. f. gain in it, it may be an advantage to shield the external amplifier, either by putting it into one of the Alcoa or similar box shields, or by placing a metal box around the coil. Under some conditions the amplifier may cause the receiver to oscillate, or the amplifier itself may oscillate. In the Laboratory no trouble was had at all, even when the external amplifier was used with receivers which had considerable gain.

MANY owners of radio receivers desire to add a stage of radio-frequency amplification in front of their set. Such an amplifier with a tube of the 201A type has a tendency to oscillate and create trouble if it has any r.f. voltage amplification in it. The answer is to use a screen-grid tube, which does not oscillate so easily. Such an amplifier is described here. In the Laboratory it has been possible to hear stations with its use that were inaudible without it.

When the unit is used with the crystal receiver described in June RADIO BROADCAST, *the receiver changes from a one-station set to one which will not only separate* WJZ *from* WEAF *under the very severe receiving conditions mentioned in the article, but will bring in all the other New York stations as well.*

No receiver has been found in the Laboratory which could not be used with this additional amplifier—it seems to be a universal unit.

—THE EDITOR.

In the Laboratory the amplifier was used with the crystal receiver described in the June RADIO BROADCAST, making it possible to receive WJZ, which is about thirty miles away, without getting WEAF, which operates within 50 kc. of WJZ and is only five miles away. Ordinarily WJZ could not be distinguished through WEAF on this crystal set. It was also possible to hear good signals from the other New York and New Jersey stations when the amplifier-crystal detector receiver was operated, although they could not be heard at all without the amplifier. In view of the extremely strong field in the vicinity of the Laboratory from WEAF, the gain in selectivity evidenced by this additional tuning circuit and its amplifying tube is considerable.

HOW THE UNIT IS OPERATED

THE operation of such an amplifier is simple. The antenna is removed from the receiver and attached to the amplifier. Then the output wire from the amplifier is attached to one of three places on the receiver. On most sets it is merely necessary to attach the output wire to the antenna binding post. On some sets which have an additional tube with an untuned antenna-ground circuit ahead of the r. f. amplifier itself, better signals will be received if the output wire is attached to the grid terminal of the first or second tube socket, or to the rotor or stator plates of the first tuning condenser. The best

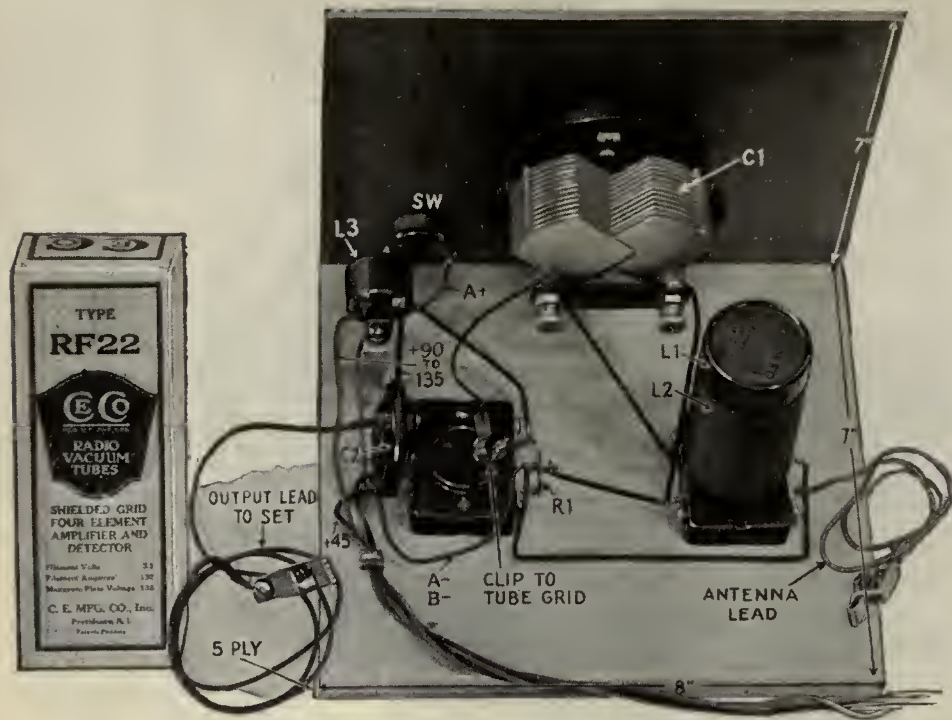


FIG. 1
Simplicity is the key note of this additional stage of r. f. amplification which can be added to your present receiver. It adds amplification and selectivity—and costs but little

place to connect the output wire is a matter to be determined by test only. There is no danger attached to such an experiment; nothing can happen if the wrong connection is made.

The receiver is then tuned as usual or to the dial setting where signals are to be expected, and the amplifier dial turned until the signals are heard. Under some conditions a slight readjustment of the receiver dial or dials may be necessary. In general, however, the external amplifier will have no effect on the receiver tuning with the exception of the first tuning condenser of the receiver's r. f. amplifier. Since the antenna is removed from the first tube of the receiver's r. f. amplifier, the tuning of this circuit may be a degree or two different from usual. The volume control remains on the receiver itself.

Power for the amplifier may be obtained from the receiver power supply unit. Several long leads may be cabled together and attached to plus and minus A, plus 45 and plus 90 to 135. These voltages are not critical. If the receiver's A-voltage supply is used, minus B will be already attached to the A supply; if an additional A battery is employed for the amplifier, minus B must be attached to it. Whether it is connected to minus or plus A makes little difference. If dry cells are used, six of them arranged in a series-parallel connection (Fig. 4) will be economical to operate. A rheostat should be used under these conditions to cut down the voltage from 4.5 to 3.3, and the C bias for the grid obtained as shown in Fig. 3. If an external battery is used, the amplifier should be grounded. If the set's battery is used, it is probably already grounded, automatically grounding the amplifier.

COIL DATA

THE coil used in this amplifier is the Remler plug-in type 550 coil, designed to cover the broadcast band with a 0.00035 mfd. condenser. If the constructor desires to build his own coil, about 90 turns of No. 24 wire on a 2-inch form with about ten turns for the antenna-ground coil will do nicely. With a .0005 mfd. condenser about 75 turns will be correct. The kind of insulation on the wire is not important.

A stage of r. f. amplification similar to the unit described here was described in the June Radio Broadcast (A Screen-Grid Booster) by Glenn Browning, and may be purchased complete from the Browning-Drake Corporation or the parts may be assembled at home. A similar unit is manufactured by the Sterling Manufacturing Company. Up to the present time, this unit has not been tested in the Laboratory.

The parts used in the unit described in this article are as listed below. Other similar parts may be used, of course.

LIST OF PARTS

C_1	1	Remler condenser, 0.00035 mfd., type 638
C_2	1	Sangamo fixed condenser, 0.001 mfd.
L_1, L_2	1	Remler inductance, type 550
L_3	1	Remler r. f. choke, No. 35
R_1	1	Frost De Luxe resistor, 20 ohms
	1	Remler dial, type 637
	1	Carter Imp on-and-off switch
	2	Remler sockets
	1	Baseboard, 7 x 8 inches, 5 ply
	1	Panel, 7 x 8 inches, $\frac{1}{8}$-inch walnut
		25 feet Celatsite Hook-up wire

To place the amplifier in operation the following apparatus will be necessary:

- 1 Screen-grid tube, UX-222 type
- 1 A Battery supplying not less than 4 volts
- 1 45-volt screen-grid voltage source
- 1 90–135-volt plate voltage source

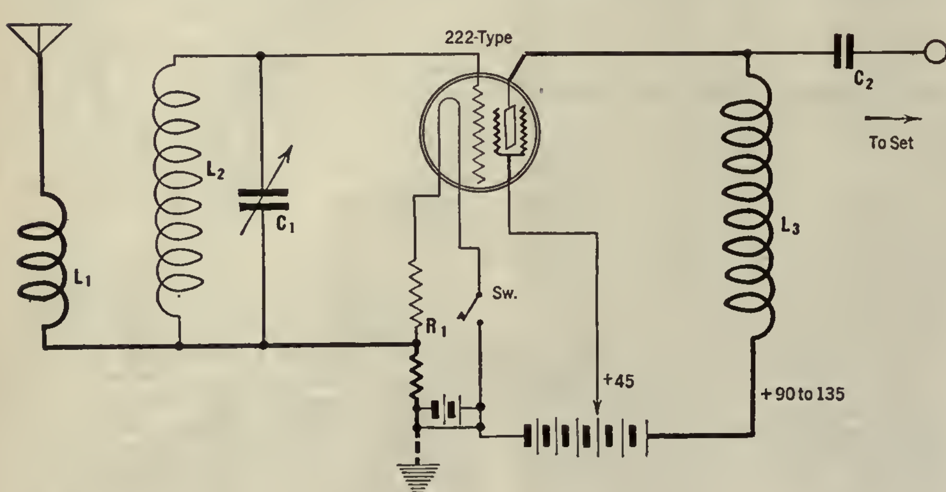


FIG. 2
The circuit diagram of the amplifier if a six-volt storage battery is used. The fixed resistor R_1 drops the battery voltage to 3.3–3.4 required by the tube and supplies a constant grid bias of about 1.3 volts

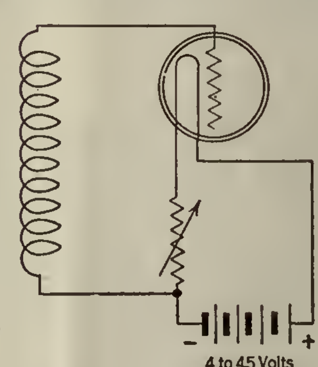


FIG. 3
If dry cells are used a variable resistor should be used to lower the battery voltage to that required by the tube. This diagram shows how to connect it in the circuit

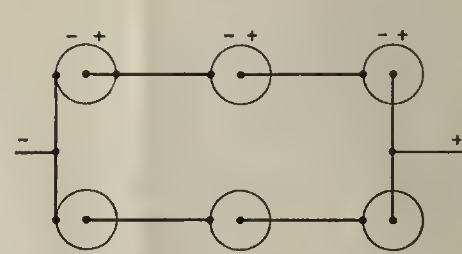


FIG. 4
Six dry cells in this series-parallel connection will supply 4.5 volts and when used to light the filament of a screen grid tube taking 132 milliamperes should last a long time

AS THE BROADCASTER SEES IT

BY CARL DREHER

Broadcast Frequency Characteristics

A QUESTION of importance is brought up by Mr. F. H. Akers of Chicago in the following communication:

There is, I think, a growing tendency among the broadcasting stations, at least around Chicago, against which I should like to raise a "squawk." I have been noticing for some time an increasing tendency for articulation to become poor and a general inability to hear spoken words distinctly. At first I looked in the set for the trouble but was not able to find it, and, checking up with other sets and with a friend working at a broadcasting station, I found that they are favoring the low audio frequencies so that their station will sound better on sets with poorer audio equipment. This seems to be a growing practice which, of course, is nice for the fellow with a poor audio amplifier, but leaves the quality not so good for the listener with fine equipment. Perhaps others are having the same trouble and are mystified at not being able to find the cause. In the long run I do not believe such practices will be good for broadcasting, because they discourage buying good receiving equipment. I do not know to what extent this is being done, as the better and larger stations do not do it, and I may be wrong in my conclusion.

I have not run across cases of intentional frequency discrimination at broadcast stations, such as Mr. Akers complains of, and doubt their prevalence in the Chicago district or elsewhere. Of course, there are numerous instances of failure to transmit essential frequencies in the audio band, but these are seldom purposeful, and may as a rule be ascribed to poorly designed or badly operated equipment. The case reported in this department about a year ago, where a station operator connected a half-microfarad condenser across an amplifer to get rid of microphone hiss, and incidentally cut out most of the tones above 2000 cycles a second, is a flagrant instance, but quite extraordinary. In this case the owner of the station liked the absence of high frequencies; it made the music "mellow," he said. He should have a dozen cheap violins smashed over his head before being handed over to the constabulary. Violins are rich in high-frequency partials. A few years ago, also, a New York station broadcast from a sea resort about eighty miles distant over an unequalized wire line. The result was about the same as in the station which eliminated carbon "rush" by the inspired expedient aforementioned. Many stations, of course, transmit only the three middle octaves of music, and the Federal Radio Commission lets them stay in business. But these are all effects of ignorance or inadequate technical facilities. The stunt which Mr. Akers describes is a different kind of offense.

If anyone has actually thought of such a device, I agree with our correspondent that the inventor had best put the idea in his cold file and forget it. Compensation in one link of an electro-acoustic chain for the defects of another section is of course no novel idea, and in some cases it is a justified, although always somewhat dubious, design resource. Something may be said in its favor when it happens to be economical and when the defects to be ironed out are quantitatively known, so that a precise compensation is possible. But receiving sets may have so many different defects that any attempt at correction of the audio characteristic at the transmitter is bound to injure as many listeners as are benefited for the time being. If the lows are allowed to predominate at the broadcast station, what is going to become of the people who have drummy receiving sets, not to mention those who have already attained a reasonable flatness in acoustic design? There is as much logic in making the station output tinny in order to help people whose receivers are down at the high end. If the stations went in for this sort of thing the audio-frequency spectrum would become as disorderly as the radio, which heaven forfend. Let the manufacturers of receivers, amateur and professional, strive for audio characteristics flat between 100 and 6000 cycles, and let those of the broadcasters who have not yet attained this reasonable ideal bend their efforts in the same direction. Plenty of the broadcasters are already ahead of this standard. I offer in evidence Fig. 1, a curve of the frequency response of the National Broadcasting Company's WEAF transmitter at Bellmore, Long Island. The station was built by the Radio Corporation and the transmitter supplied by the General Electric Company (Advertisement). The observations for the curve were made by Mr. Raymond Guy, and I will vouch for them as authentic. That is a pretty curve, and for practical purposes it would be no better if it were a horizontal line drawn with a ruler between 30 and 10,000 cycles, because the irregularities in the characteristic are too small for the most sensitive human ear to detect. Alas, not all of this lovely curve is utilized by the stuff which gets out over the wire line. I reproduce it, however, so that Mr. Akers may feel assured that some broadcasters strive to let the efforts of the artists go out to the world without any acoustic infidelites. Those who do not at least make that effort are, I believe, in a very small minority.

Low Voltages are Dangerous

WE HAVE certainly stressed the danger of coming into contact with high-tension conductors in broadcast stations frequently enough in this department. Perhaps not enough has been said about the menace of relatively low-voltage circuits. The following account of a most unfortunate accident, through which a well-known telephone and radio research engineer lost his life, may give pause to those who think nothing can happen to them on 110 or 220 volts. The clipping is taken from the New York *Times* of April 13, 1928.

> Deal, N. J., April 12.—H. R. Knettles, 31 years old, a member of the technical staff of the local Bell Telephone laboratory, was killed early to-day when he came into contact with a low-voltage power circuit. His body was found on the floor by other members of the staff.
>
> He had entered an enclosure in which the only electric power was a 240-volt alternating current supply, and was probably killed, it was said, when moisture in the air caused a short circuit with his body. Pulmotor efforts at resuscitation failed.

The seriousness of an electric shock is dependent, of course, on the power dissipated in the victim's body, rather than on the voltage impressed. The "medical" induction coils which were popular ten years ago used to generate several thousand volts, but the available power limited the current to a few milliamperes, so that no damage to tissue could result. When the power is not so limited, and the resistance presented by the body happens to be low, moderate voltages may cause death. Every year a sizable number of persons are killed in bathtubs on 110-volt circuits. Standing in water, and with wet hands, they touch a defective electric light fixture. Under these conditions the resistance of the body is reduced to a few hundred ohms. The resulting current may be of the order of an ampere. Any considerable fraction of an ampere, especially when it passes through vital organs or nerve ganglia, is likely to cause grave injury or to kill outright. In handling high-power, high-voltage circuits, in general, contact means certain death. In the case of high-power, low-voltage circuits one gambles with the electrical resistance of one's body. If it happens to be low a few hundred volts will send a man to eternal sleep just as surely as a few thousand.

The story about moisture in the air, in the case of Mr. Knettles, is, of course, a reporter's misconception. Apparently the engineer came into contact with the conductor through his head, which may have been moist. Anyone who has ever made a good contact with a 220- or 240-

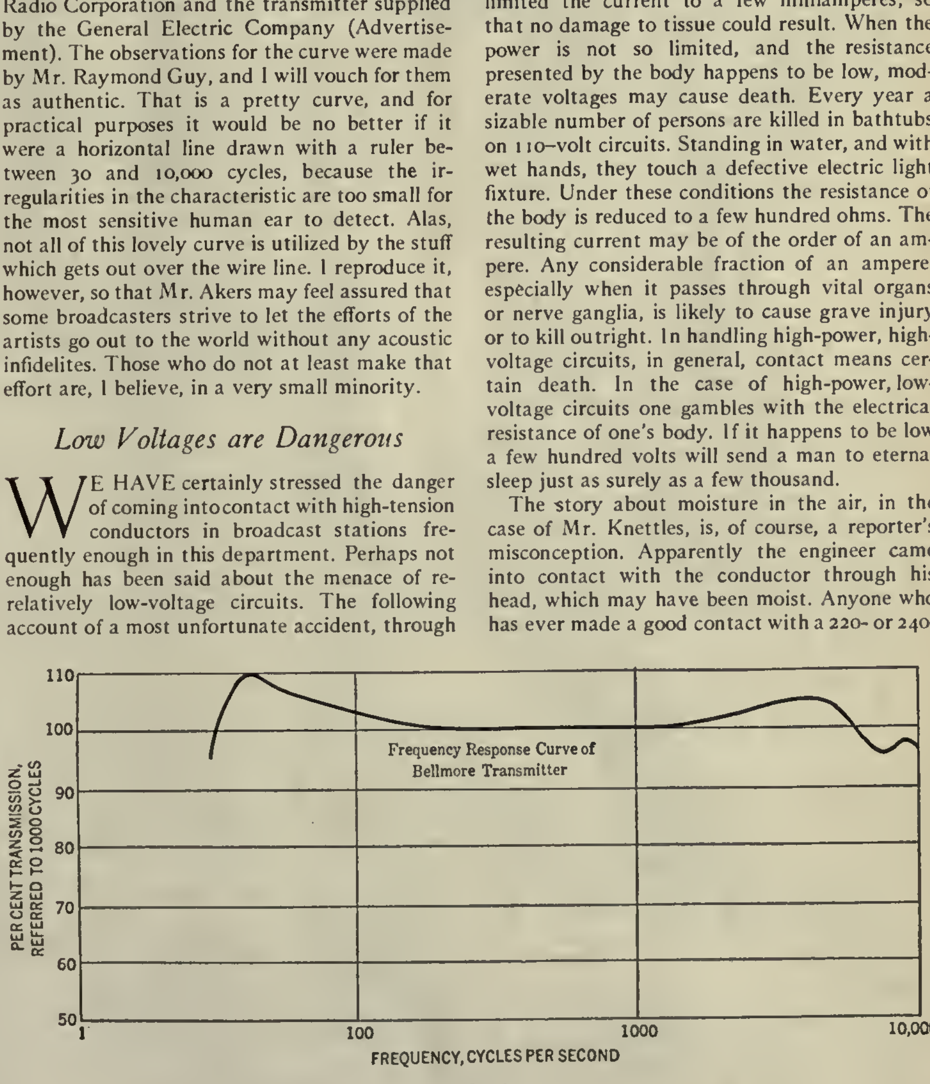
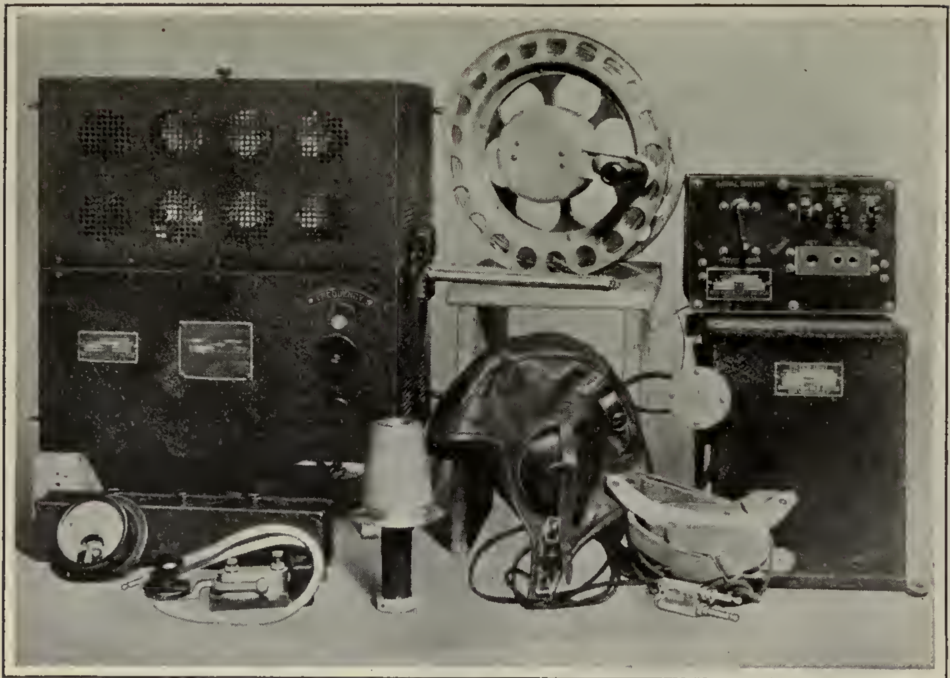


FIG. 1



THE R. C. A. 300-WATT AIRPLANE SET

volt circuit knows what a terrible shock can be sustained on such potentials.

Broadcast technicians, used to handling potentials of the order of thousands of volts, become contemptuous of lower voltages. They are making a mistake. As one gets older in this business one becomes more and more reluctant to fool with electricity on any voltage at all, when power is known to be behind the terminals. As a young man, just out of college, I used to test for a live circuit on 110 and 220 volts without hesitation, using my fingers. On one occasion I actually touched my thumb and forefinger to a 440-volt line feeding a telegraph quadruplex to see what it would feel like. I did it in such a way that the movement would disengage me, and there were spectators present, but it was a pretty idiotic stunt. Nowadays, I won't touch the metal of a 110-volt circuit if I can help it. There are plenty of test-lamps to be had for twenty cents. And, incidentally, these warnings hold for receiving set rectifiers as much as for broadcast transmitter apparatus. One of these days some enterprising broadcast experimenter is going to be burned up on the 500 volts from his power rectifier, when he forgets to turn off the electricity before putting his hands into the case. A few electrocutions are imminent. All I can do is to point out the fact and wait for the newspaper reports.

Commercial Radio Publications

RADIO CORPORATION OF AMERICA:
"Aircraft Radio Equipment"

THIS is a beautifully printed pamphlet of specifications and illustrations of three types of airplane radio stations marketed by R.C.A. It is issued by the Sales Department of this company, at 233 Broadway, New York City, which will supply quotations on request. The three types of transmitters and receivers available for planes of different sizes are described as follows:

ET-3652—Weight: 86½ pounds. A light weight transmitting and receiving equipment for installation on the smaller types of "single seater" airplanes. Rated at 10 watts, it will, under favorable conditions, transmit via radiotelephony a distance of approximately 25 miles, or by radiotelegraphy (c.w.) a distance of approximately 75 miles.

ET-3653—Weight: 132¾ pounds. A medium weight transmitting and receiving equipment for installation on practically any type of airplane. Rated at 100 watts, it will, under favorable conditions, transmit via radiotelephony a distance of approximately 75 miles, or by radiotelegraphy (c.w.) a distance of approximately 300 miles.

ET-3654—Weight: 202 pounds. This transmitting and receiving equipment is designed for use on large aircraft where long distance communication to ground stations and other aircraft is desired. Rated at 300 watts, it will, under favorable conditions, transmit via radiotelephony a distance of approximately 200 miles, or by radiotelegraphy (c.w.) a distance of approximately 500 miles.

The above ranges are stated by the manufactures to be approximate, yet conservative, so that at times a considerable increase in range may be secured.

The following major units are included in the 10-watt Model ET-3652 equipment: 1 transmitter, including 3 UX-210 radiotrons; 1 control unit; 1 terminal box; 1 receiver; 1 filter unit; 1 antenna with wire (300 ft.); 2 antenna weights; 1 fairlead (an insulating tube in which the antenna lead is carried out through the fuselage of the plane); 1 aircraft anti-noise microphone; 1 wind-driven double-current generator; 1 Deslauriers air propeller; 1 antenna ammeter; 1 flame-proof key; 1 helmet and phones, cord and plug; 1 set inter-connecting cable.

The rating of these airplane transmitters is based on power in the antenna, so that the Model ET-3652 will deliver 10 watts of r. f. power to an antenna of the trailing type, 80–130 feet long. The frequency range available is 2250–2750 kilocycles (133–109 meters). Three UX-210 tubes are used, one as a master oscillator, one as a radio power amplifier, the remaining one as a modulator. With voice input a 50–60 percentage modulation is reached, the Heising system of modulation being used. The quality of reproduction is stated to be very good, but no figures as to the actual audio-frequency range are given.

The receiver is a simple and compact 5-tube affair, with two stages of neutralized radio-frequency amplification, a regenerative detector, and two stages of transformer-coupled amplification. The receiver derives its power supply from the same generator which feeds the transmitter, suitable filters being interposed.

The larger transmitters (100 and 300 watts in the antenna for telegraphy) carry substantially the same parts as the 10-watt outfit, with the addition of spares, owing to the greater weight permissible; and, of course, in proportionately larger sizes where the power requirements are greater. The 100-watt (ET-3653)model uses a UX-210 tube in a Hartley master oscillator circuit, followed by a neutralized power amplifier in the form of a UV-211 tube. This power amplifier is modulated for telephony by the Heising system.

The receiver for this set covers a 3750–2200 kilocycle (79.95–136.3 meter) range. It is slightly heavier than the receiver provided with the 10-watt outfit. The antenna wire, carried on an insulated reel, is copper-clad steel. Ten antenna weights are provided. In the case of this transmitter and receiver the wind-driven generator supplies voltages of 1000 for the plates and 10 for the filaments. The 10-volt winding also feeds an inter-communicating telephone system between the pilot and operator. The maximum total output of the generator is 800 watts. Normally it provides 450 milliamperes at 1000 volts for the plates and 9 amperes at 11 volts for the filaments and excitation circuits. The housing is of stream-line design. As long as the plane is in the air the generator maintains a speed of 4000 r.p.m., regardless of wind speed or load, the regulation being automatic through a centrifugal governor which changes the pitch of the propeller blade to compensate changes in speed.

The 300-watt (ET-3654) outfit utilizes 1 UV-211 tube as a master oscillator, 3 UV-211's as power amplifiers, 1 UV-211 as a speech amplifier, and 3 UV-211's as modulators. Presumably the object of employing such a large tube as a 211 as a microphone amplifier was to confine the set to one kind of transmitting tube. The master oscillator is a modified Colpitts circuit, with its tank circuit exciting the power amplifier, which in turn feeds the antenna through a coupling transformer. Part of the d.c. voltage across the power amplifier grid leak is used to bias the speech amplifier and modulators.

One novel design feature of this set is the inclusion, in the microphone transformer, of a side-tone winding which is connected across the headphones of the operator and pilot and across the receiver output. The headphones are thus used for interphone communication, monitoring radio telephone transmission from the plane, and for reception of incoming signals, whether telegraph or telephone. Operation is possible from either the pilot's or radio operator's seats in the plane, a magnetically controlled send-receive relay being provided. The general features of the 300-watt equipment do not differ, except in size, from those of the 100-watt model.

In all airplane installations adequate electrostatic shielding of the aircraft engine is essential if any kind of reception is to be expected. Another precaution which cannot safely be neglected is the bonding of all metal parts of the plane by means of electrical conductors, to eliminate the danger of sparking between surfaces.

No. 5. August, 1928.

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

The Fada 480-B

RADIO receivers designed for a.c. operation fall into three general classes, i.e., those using a.c. tubes, those using standard battery type tubes with the filaments connected in series, and those using standard type tubes with the filaments connected in parallel and energized from an A-power unit. This latter type of receiver may be operated from batteries when one desires or may be made completely light-socket operated by the use of A- and B-power units. Such a receiver is the Fada 480-B, a circuit diagram and photograph of which is given in this data sheet.

The Fada 480-B receiver is a dual control set, the right-hand drum dial (in the diagram) tuning the antenna stage and the left hand drum dial controlling all the other tuning condensers in the set. Small trimming condensers are placed across each main tuning condenser so that the several tuned circuits may be accurately aligned. The tuning condensers are substantially made with heavy plates and large bearings so that they will operate smoothly and hold their calibration over a very long period of time. The receiver may be operated from either a loop or an antenna, either indoor or outdoor.

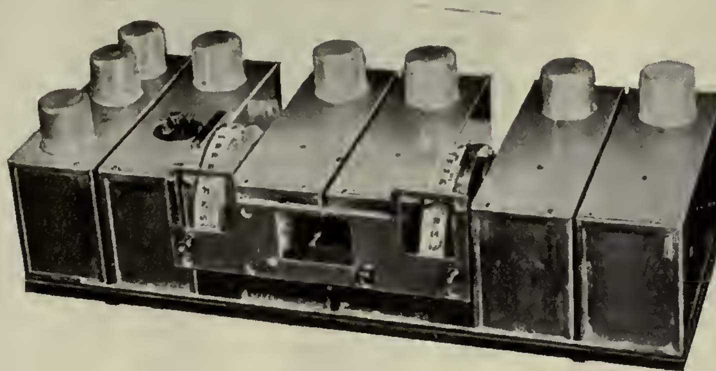
This eight-tube receiver consists of four stages of tuned radio-frequency amplification, a detector and either two or three stages of transformer-coupled low-frequency amplification, depending upon the position of the toggle switch indicated at the top of the diagram. All of the r.f. stages are shielded, the plate leads are all bypassed with 0.5 mfd. condensers and each stage is neutralized by means of center-tapped primaries on the r.f. transformers—a type of neutralization familiar to many as the so-called "Roberts" method. An r.f. choke coil, L_1, is placed in the positive filament lead of each of the r.f. tubes to keep any a.c. currents out of the plate supply, where it might produce common coupling and cause oscillations.

A separate shielded compartment contains the audio-frequency amplifier. This compartment is at the right in the circuit diagram and contains the sockets, three audio transformers, the output choke, output condenser, and bypass condensers. By means of the toggle switch on the panel either two or three audio stages may be used; with the switch thrown to the No. 8 position all three stages are used, while in the No. 7 position only two stages are used. Tubes of the 201A type are used in the audio amplifier as well as in the detector and r.f. tube sockets. A power tube of the 171A type is recommended for use in the output of the amplifier. The power circuit contains in its output a choke-condenser combination to protect the loud speaker from the d.c. plate current. The choke is marked L_2 in the diagram and the output condenser C_1. The condenser has a capacity of 1.0 mfd.

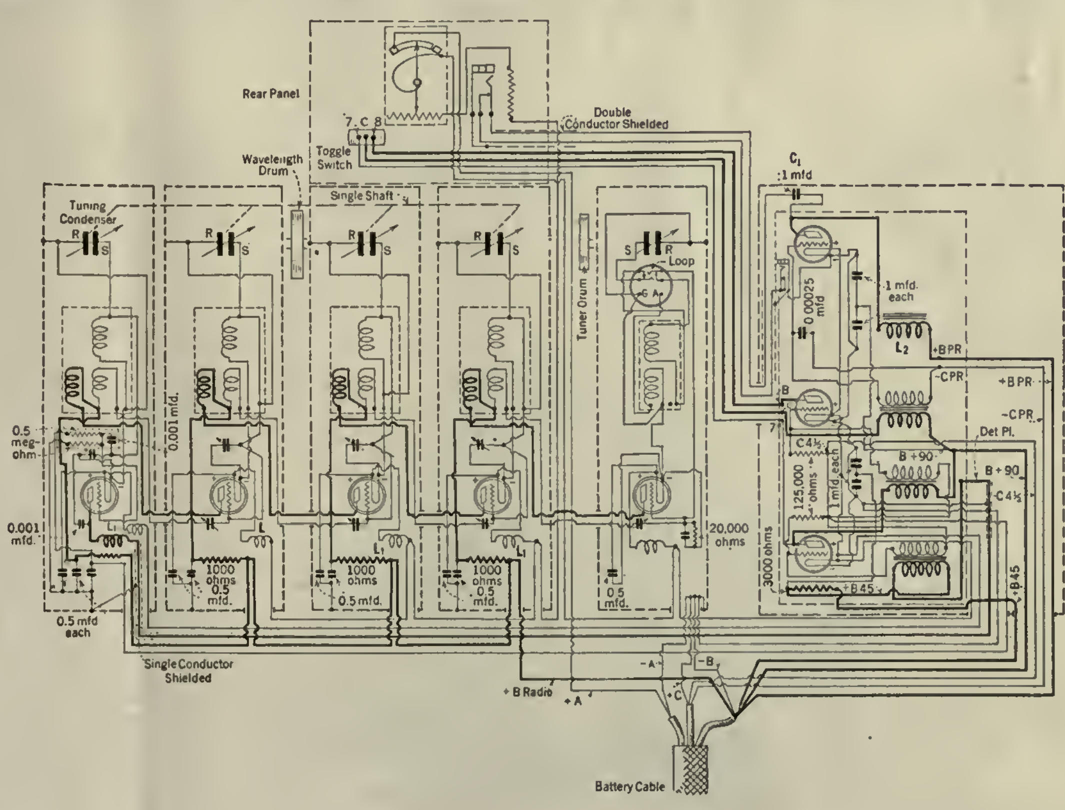
An A-B-C power unit is made by the same company to be used with their receiver; The B and C unit uses a type 280 full-wave rectifier to supply the necessary plate and grid bias voltages to the set. The A-power unit consists of a rectifier-filter system designed to supply approximately six volts and currents up to 2½ amperes. This supply is used for the operation of the filaments of the tubes in the receivers and the output is sufficiently well filtered to give quiet operation. The alternating line current is converted to pulsating direct current by means of a dry type rectifier manufactured by the Elkon Works, which is supplied with the correct amount of voltage from the secondary winding of the transformer. The pulsating current is then filtered by means of high-capacity dry A type condensers and properly designed choke coils. There are two adjustments provided; one is for various line voltages between 90 and 130 volts, and the other is used to adjust the output of the device for the operation of six, seven, or eight tube receivers.

These 6-volt A-power units are furnished in two types: one for the operation of six-and seven-tube receivers and another for the operation of six-, seven-, or eight-tube receivers. Both of these types are supplied in two models: one for operation on either 50- or 60-cycle alternating current and one for operation on from 25 to 50 cycles.

A VIEW OF THE CABINET



THE SHIELDING ARRANGEMENT



THE CIRCUIT OF THE FADA 480-B

No. 6. **August, 1928.**

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

The Federal Ortho-sonic Seven-Tube Receiver

THIS set is a good example of a receiver designed for a.c. operation using standard 201A type tubes in a series filament arrangement and supplied with filament current from a rectifier filter system employing a Raytheon type BA high-current rectifier.

The seven tubes in the receiver are arranged as follows: four of them are used as radio-frequency amplifiers, one is used as the detector and the other two are used as audio amplifiers. A 171A type tube is used as the power tube. The order of tubes in the series filament arrangement is: First r.f., second r.f., third r.f., fourth r.f., first a.f., detector, and second a.f.

In an efficient four-stage radio-frequency amplifier careful design is essential if the receiver is to be stable over the entire broadcast band. To promote stability in this receiver all the r.f. stages are completely shielded, radio-frequency choke coils are placed in each leg of the filament of each of the tubes used in the r.f. amplifier, each plate supply lead to the r.f. tubes is filtered by the use of resistances, and bypass condensers, and finally each stage is carefully neutralized, the small inductance coils, L, in the filament circuits forming part of the neutralizing system. The five variable tuning condensers are ganged to a single drum dial control, a small vernier condenser being used to obtain fine adjustment of the tuning system.

The audio amplifier is of standard design. It is interesting to note that the first audio-frequency tube has about 70 volts applied to its plate and that a 5-volt negative bias for the grid is obtained by connecting the grid return from the transformer to the detector tube filament, so that the 5-volt drop in the filament of this latter tube is impressed on the grid of the first audio tube. Bias for the second audio tube is obtained from the voltage drop across resistance R_5, in the power unit. The cores of the two audio transformers are grounded to prevent any possibility of audio-frequency oscillations due to extraneous coupling between the two transformers. Bypass condensers are also connected at various points in the audio amplifier to prevent common coupling in the power supply. The detector and audio amplifier apparatus is housed in a single compartment, entirely separate from the radio-frequency amplifier.

THE RECEIVER IN ITS CONSOLE

Only two values of plate voltage are supplied to the receiver from the power unit, 180 volts and 70 volts. The latter is reduced to 45 volts for the operation of the detector by means of a 160,000-ohm resistance connected in series with the detector plate circuit. Volume control is accomplished by varying the potentiometer, P, which controls the amount of voltage applied to the plates of the r.f. tubes.

A grid leak condenser type of detector is used. The grid leak has a value of one megohm and the grid condenser has a value of 0.0002 mfd. Because the input capacity of a tube when used as a detector is somewhat less than when it is used as an amplifier, it is necessary to connect a small midget condenser, across the detector input so that the last tuning condenser will gang properly with the other tuning condensers. The output of the detector contains a fixed resistance in series with the plate circuit to keep the r.f. currents out of the audio amplifier. In addition, a bypass condenser is connected between the plate of the detector tube and the negative side of the detector tube filament.

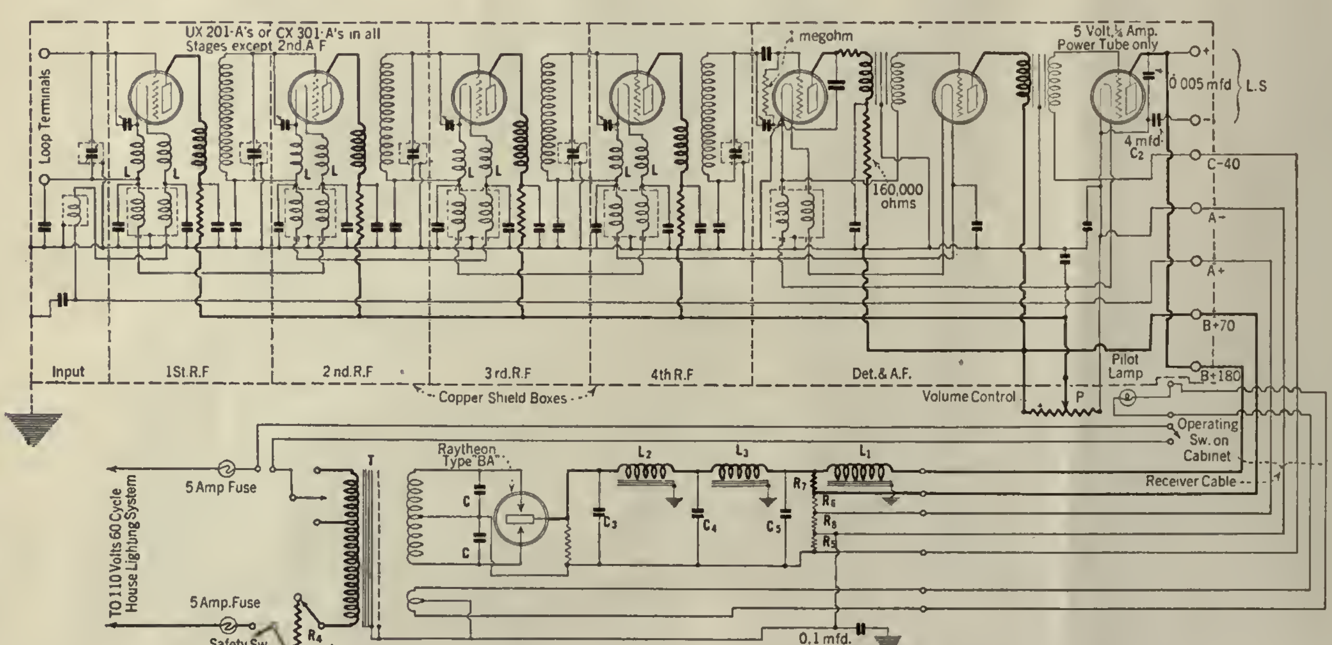
The loud speaker is insulated from the direct current in the plate circuit of the 171A type power tube by means of a choke-condenser combination. The condenser, C_2, has a capacity of 4 mfds. The output choke, L_1, is located in the power unit.

The power unit supplies all the A, B, and C voltages required for the operation of the receiver. The power transformer, T, is arranged with three taps on the primary so that the installation may be adjusted for low, medium, or high line voltages. The high-voltage secondary of the transformer supplies the Raytheon BA rectifier. The output of the rectifier feeds into the filter system which consists of the usual two filter choke coils, L_2 and L_3, and three main filter condensers, C_3, C_4, and C_5. The output of the filter goes to the resistance bank from which taps are taken for the A, B, and C voltages required for the operation of the receiver. Bypass condensers are not necessary across these resistances, as all the necessary bypassing is placed in the receiver itself.

An additional 5-volt winding is placed on the transformer and is used in this model to supply current to the pilot lamp located on the panel of the receiver.

An adjustable resistance, R_4, is connected in the primary side of the power transformer so that small variations in line voltage may be compensated. The equipment is also protected by the inclusion of two 5-ampere fuses in the primary circuit.

This receiver is designed for operation on a loop type antenna. The advantages of loop operation, i.e., convenience, directional properties, better signal-to-static ratio, are well known. In the model illustrated in the photograph the loop is located on one of the doors of the cabinet.



THE CIRCUIT OF THE FEDERAL ORTHO-SONIC RECEIVER

Is the Highbrow Entitled to a Program of His Own?

By John Wallace

WE ARE in receipt of several letters, as a result of our remarks in the May number, condemning us for an alleged desire to see radio go highbrow. We are reminded by the writers that "radio is for the butcher, the baker, and the candle stick maker." Further, they bring to our attention the highly original point that "Radio can't please everybody. The great mass of people can't be neglected. Would you deprive them of their entertainment to please a dubious minority of highbrows?" All this because we had set forth an appeal that a little brains be applied to the devising of continuity programs so that they might cease being an insult to the intelligence.

In reply to such unmeditated protests we wonder: if instead of an article on radio we had inscribed a lengthy plea that larger areas in Chicago be devoted to playgrounds, would not these same correspondents have written in protesting, "Would you have our great office buildings, hotels, and theaters leveled to the ground to provide space for a lot of silly pastures which probably wouldn't be used anyway?"

The absurdity of such reasoning lies in its assumption that there isn't room for both. Because we, and others of the "highbrow" contingent, clamor in print, and otherwise, for more highbrow stuff, does not mean that we would have the air filled with it to the exclusion of all else. If we ask for a loaf, persistently and again, it is not because we expect even half a loaf, but because we hope thereby to gain a few crumbs of the general broadcast fare.

There is not the slightest danger that the masses will ever be neglected by the radio entertainment purveyors. They present far too large a potential market for cleansing powders, tires, tooth paste, hair tonic, and linoleum for anything like that ever to happen. They will continue to get the popular stuff they want without lifting a finger. But if the high-school-graduated minority wants to keep some little attention directed toward itself it will have to continue to beg for it, to write to its congressman, and to stand on its head as means of gaining notice.

This is doubtless as it should be. Radio, by rights, belongs to the unlettered. They are entitled to make demands upon it. The lofty-domed minority can, with justice, do no more than make *requests* of it. The fairness of this arrangement should be evident in view of this fact: radio is the only agent of dissemination that has made its appearance since printing was introduced several centuries ago. Through all those centuries printing has been the rightful possession of the lettered. You may point to the vast stacks of popular periodicals that ornament the news stands as evidence to the contrary, but that demon, Statistics, will show this to be but a drop in the bucket. If all the books and pamphlets and periodicals that have been printed since Mr. Gutenberg invented movable type back in 1456 were placed end to end they would stretch from New York to San Francisco and then some.

And if they were placed in the order of their brow elevation, with *Weird Stories* and *Liberty* at the beginning of the stack and the *Novum Organum* or Mr. Einstein's book at the finish, it would be found that the lowbrow section would peter out somewhere around Elizabeth, N. J., while literature and scientific writings, philosophy, and other weighty tomes would stand in solid ranks for many thousands more of miles.

In other words the printing press operators haven't really given much of a whoop for the masses over their 472 years of production. So if now this new contraption, radio, decides to put in its major effort in behalf of *hoi polloi* there can be no great cause for complaint.

We trust we have by now made it quite clear that we have neither any desire to deprive the candle stick makers of their rightful enjoyment of any old kind of radio program piffle they may want, nor any slightest suspicion that any words of ours, or of any one else's, could succeed in having them deprived of it.

But since the printing press operator not infrequently takes off his silk hat and his kid gloves and runs off an edition of the *Police Gazette*, it seems to us that it might be in some way contrived that the radio lords dish up a little program for the highbrows without, at the same time, keeping one eye on the lowbrow and both thumbs on his pulse. In short, we think it is high time that some one, somewhere, put on a program with a little touch of sophistication to it.

Once before we published in this department a list of the findings we made by starting in at the top of the dial and recording everything that was available from the top to the bottom. We offered this list, a record of forty-one stations, as a cross section of what was on the air, and a rather lugubrious cross section it was. After its publication we received complaints to the effect that the general mediocrity of the listed turns was due to the fact that the listening was done in Chicago instead of New York. This objection is not valid, for of the seven or so first rate stations in New York, three are available in Chicago by chain. The three or four we might have missed couldn't have done much to boost the average of the forty-one stations examined.

The following list, made from 8:30 to 9:30 of a summer's eve, is, on account of the late sunset, confined almost exclusively to Chicago stations. Its general tone would doubtless have been slightly elevated had such Eastern stations as WGY and WBAL been available but, after all, we don't all live on the East Coast, so we herewith present our last night's list as a reasonably representative cross section of what's on the air:

1. Dance orchestra
2. Hawaiian guitar
3. Dance orchestra
4. Soprano singing ballad
5. Hymns
6. Tenor solo, popular songs
7. Orchestra, popular
8. Mixed quartet, American Indian song cycle
9. Solo trombone
10. Piano and violin, popular music
11. United Synagogue broadcast
12. Popular duet
13. Dance orchestra
14. Baritone solo, semi-classical
15. Dance orchestra
16. Dance orchestra
17. Male quartet
18. Orchestral program with continuity
19. Mixed chorus, light opera
20. Concert ensemble, popular music
21. Orchestral program with continuity
22. Popular singing
23. Banjo solo
24. Operatic selections

We propose neither to praise or berate this listing. We present it simply as a record of the facts. If it meets with your approval you can take it to be an endorsement of your opinion that all's well with radio. If it meets with your displeasure you can cite it as proving the contrary. However, we might be allowed to call attention to this: of the twenty-four programs encountered on the one hour trip across the dial, twenty-one were popular in make-up. The only exceptions were numbers eight, nineteen, and twenty-four. Two of these were "light" and only one could by any stretch of the imagination be labeled highbrow. That, the last named, happened to be WJZ's excellent organization, the Continentals.

Thus it seems apparent that radio programs are directed, by an overwhelming majority, at the lowbrow. This does not mean that the highbrow may not also enjoy some of them, but it does mean, just exactly as it says, that precious few programs are leveled

HE SUPERVISES WBAL'S ORCHESTRA

Michael Weiner brought a love for music when he immigrated to this country from Russia as a boy. Now he supervises the orchestral programs for which WBAL *is famous*

ONCE A WEEK AT WOC

The Voss Vagabonds, orchestra and mixed quartet, is one of the most popular features broadcast from the Davenport, Iowa, station

at the highbrow. He is simply tolerated, and privileged only to gather what crumbs he may from his numerous brothers' table.

There is probably some very good reason which we have stupidly overlooked—but why, oh why, doesn't some program sponsor get up a program that is aimed directly at the individual of mildly sophisticated taste? Evidently a manufacturer of paper picnic plates or overall buttons wouldn't want to sponsor such a program, but there must be somewhere in this country a manufacturer whose product coincides with the needs of a medium-highbrow audience.

To arrange a sophisticated program would not be difficult, hardly a bit more difficult than arranging a banal one. It would require only two things, first, that an individual of some sophistication get up the program and, second, that he be allowed to "let himself go."

The sponsor of a such-like program would have heavy sledding at first, for the reason that he hasn't a potential audience at the present time. Individuals who make some cerebral demands on their entertainment do not listen to the radio. This is not, as is popularly supposed, because of some silly prejudice against radio itself, but simply because their various attempts at listening have convinced them that radio programs are not, at present at least, intended for the likes of them.

We do argue, though, that such an audience could be worked up. If a genuinely witty and sophisticated program made its début, its appearance would excite all the attention that any rarity does. Mr. Tallbrow would remark to Mr. Highdome on the morning train, "I almost died laughing at the Rolls Royce Hour last night." And Mr. Highdome, knowing Mr. Tallbrow's swell taste, would immediately rush out and buy himself a receiving set.

That no such program now exists is apparent to anyone who has tried looking for it. There are highbrow musical programs, and excellent ones, but they are always tempered with popular selections to widen their appeal. That is all right, too. But there ought to be at least one program that would make no concession to popular taste and which would make it snootily apparent that it didn't give a tinker's dam for the man in the street.

Pat Barnes——

Chicago's Gift to the Radio World

is just the right sort of a heading to put on a brief paragraph about said person, its wording being quite in character with Mr. Barnes' style of presentation. But, quite seriously, Mr. Barnes is probably the most individual thing Chicago has to offer. If you have never sought out one of his programs through WHT you should without delay.

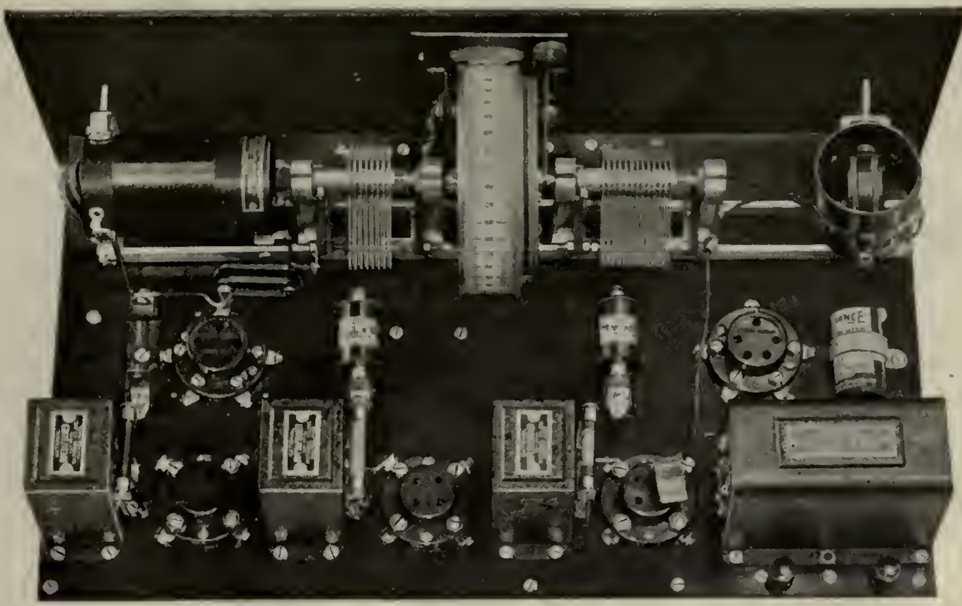
Mr. Barnes is an announcer-impresario-artist of the "heart-to-heart" type—the type which was so prevalent in the first years of radio, and which has now largely disappeared. Comparisons are odious, and so forth, but we cannot refrain from comparing him to Roxy. Barnes' delivery is of the same general style as Roxy's—personality-plus stuff. But where Roxy generally gives this particular listener somewhat of a pain, Pat Barnes pleases him enormously. This, we grant, is simply a matter of personal reaction, for Pat Barnes seems to us convincing, whereas we always have a feeling that Mr. Rothafel is simply acting a rôle. Of course, analytically, we realize that Barnes is acting, too. No one with the intelligence he displays in concocting his programs could be as witlessly maudlin as he makes himself sound—but he does it so infernally well. After all, no matter how unmomentous a thing a man picks out to do, if he does it surpassingly well it is worth attending to.

The bit of Mr. Barnes' program which we heard to-night included the reading of a perfectly banal poem with a moral. But the reading of it, the enunciation, the phrasing, the nuances of expression were simply perfect, and infinitely better *in toto* than a selection from Shakespeare poorly delivered. Then he sang "Chloe"—he has a good voice—and interpolated a recitative passage of heart-rending cries of anguish for "Chloe, where art thou?" which was the veriest melodrama and consisted in tearing passion to tatters. But who cares? It was convincing anguish and genuine passion. And then the elegant little choke in his voice when he bids his audience "Good night" . . . but try him out yourself some time.

Identification Marks of European Stations

IT MUST be a pleasanter, because more varied, existence to be a radio reviewer in England. If things on the Island get too dull he has but to fish around for Continental stations and get a nice assortment of languages and varying ideas about broadcast fare. This from the reviewing department of Jay Coote in *World-Radio:*

During my nightly trips around the ether I have particularly noticed that many Continental stations have either made some alterations in their interval signals, or adopted new methods to identify themselves to distant listeners. The adoption by numerous studios of the ubiquitous metronome, to say the least of it, was becoming monotonous. Rome, instead of using two bells, has now added a further one, and between items you may now hear the notes A, C, F in pure crystal tones. By this means a very pleasant series of sounds is obtained. Munich appears to have dropped its Morse call, and in its stead opens its transmissions with a long-drawn-out deep note resembling that of an organ, although I feel sure it is produced by some electrical gadget. Again, PTT, Paris, which for a short time had adopted the call of the cuckoo to its young, at the request of its admirers, has withdrawn the signal and is, I understand, seeking some other noise more befitting its broadcasts. Radio Toulouse still possesses its alarm clock; it can be nothing else, and its spasmodic *tock-tock* preceding each item is at times peculiarly irritating. To the credit of its announcer, however, it must be said that the call *Radio Toulouse*, clearly enunciated, is never omitted between items in the programme. It is particularly galling to hang on for some minutes in the hope of identifying a station, and to find oneself rewarded by *Allo! Allo!* followed by an almost incomprehensible mumble accompanied by spark or atmospherics. Why do so many announcers persist in dropping their voice at the moment the name of the city is broadcast?



THE A. C. MODEL OF THE NATIONAL SCREEN-GRID FIVE

Operating the National Screen-Grid Five

By James Millen

IN THE May issue of RADIO BROADCAST *Mr. Millen described the construction of a Five Tube Screen-Grid Receiver. Since this article appeared Mr. Millen has received many letters from builders of the set many of whom desired further information on how to operate it. The operating suggestions and trouble finding hints which are given in this article should therefore prove interesting to those of* RADIO BROADCAST'S *readers who have constructed this set.*

The description in the May issue described the d. c. operated model. The availability of a.c. screen-grid tubes has now made it possible to operate this receiver from the light socket, and the circuit diagram and photograph of the a.c. model are to be found in this article.

—THE EDITOR

WHEN the National Screen-Grid Five was designed, it was with the idea of making available to the radio public a receiver that could be easily constructed by the average fan; that would involve no difficult mechanical work in its construction; that would prove sufficiently selective to bring in a few distant stations while the locals were still on early in the evening; that would be easy to tune; and that would not require the use of a conventional antenna.

That these results and even more have been successfully achieved is well proved by the many enthusiastic letters received from readers who have actually built the receiver. One New York City resident wrote that he received KFI, Los Angeles, the first night he tried the set, while letters and phone calls were also received from a number of New England fans who were consistently obtaining far better dx reception than the designer had even hoped possible.

As was pointed out in the previous article, the set itself is an improvement on the original National Browning-Drake Circuit, in that the r.f. transformer has been redesigned to use the new UX-222 screen-grid tube; and the layout and design of parts have been altered to provide for single control tuning and simplicity of wiring.

From the contents of a number of the letters received, it would seem that there are a few questions of rather common interest regarding accessories, operation, and variations in design of the Screen-Grid Five.

THE CORRECT RESISTORS

PERHAPS one of the most important questions that have come up is in regard to the values of filament equalizers or ballasts specified and indicated in the circuit diagrams. The values given were in ohms, which is the system being used by most filament resistor manufacturers at present. The $\frac{3}{4}$-ohm resistor is one which when used with five $\frac{1}{4}$-ampere tubes, will drop the 6-volt filament supply down to the 5 volts required. While only four $\frac{1}{4}$-ampere tubes are used in the set, the current drawn by the 222 plus that drawn by the dial light is equivalent to an additional $\frac{1}{4}$ ampere. The 15-ohm equalizer is used to decrease the five volts available across the filaments of the large tubes down to the 3.3 volts required for use across the 222 tube filament.

In a few cases where trouble has been reported due to the receiver lacking sensitivity, it was found that the difficulty was caused by the use of a 22-ohm filament resistor rather than a 15-ohm unit. The 22-ohm filament ballasts are made for use in cases where the UX-222 is operated directly from six volts and not from five volts, as in the case of this receiver.

In other words, the number 22 designation should not be misconstrued to mean that this resistor is the proper one for use with the UX-222 tube under all conditions.

When a type 22 filament ballast is used with the National Screen Grid Five, the filament voltage on the 222 is too low and the receiver is insensitive. Another cause of lack of sensitivity, which at the same time also results in lack of selectivity, is the failure to "line up" the two tuned circuits.

Perhaps, in order for the operator to become fully impressed with the importance of this adjustment, it would be well to loosen the condenser rotors from their shafts and tune in several local and semi-local stations by separately adjusting each condenser. Then try detuning one of the two condensers and note the difference in results. It might also be well at this same time to study the operation of the antenna variometer or trimmer. With the antenna variometer rotor in mid position detune the larger variable condenser and then retune by means of the trimmer.

Before fastening the condensers to the dial shaft again, tune in a local station with a wavelength somewhere around 360 meters. The antenna trimmer should be in mid-position.

WHAT TUBES TO USE

WHILE the use of a good 200-A detector tube (when the grid leak return has been shifted from the positive to the negative side of the filament circuit) results in increased sensitivity, the lack of stability and the noisy operation encountered offsets these advantages.

Where a sensitive detector tube is desired for dx reception, it is recommended that a high-mu tube such as the UX-240 be employed. While not generally considered as satisfactory as the 112A for all-around use, the 240 will be found of worth-while aid on out-of-town reception. Due to the difference in inter-electrode capacity of the 112A, 200A, and 240, it is necessary to readjust the trimmer and the tuning condensers when changing from one detector tube to another. In some instances, it may even be found necessary to reset the position of one of the variable condenser rotors, as previously described.

There seems to be a trend upon the part of many set builders at present to use smaller values of grid condensers with correspondingly higher values of grid leaks. While the use of a 0.0001-mfd. grid condenser with a 4- or 5-megohm leak will generally result in slightly

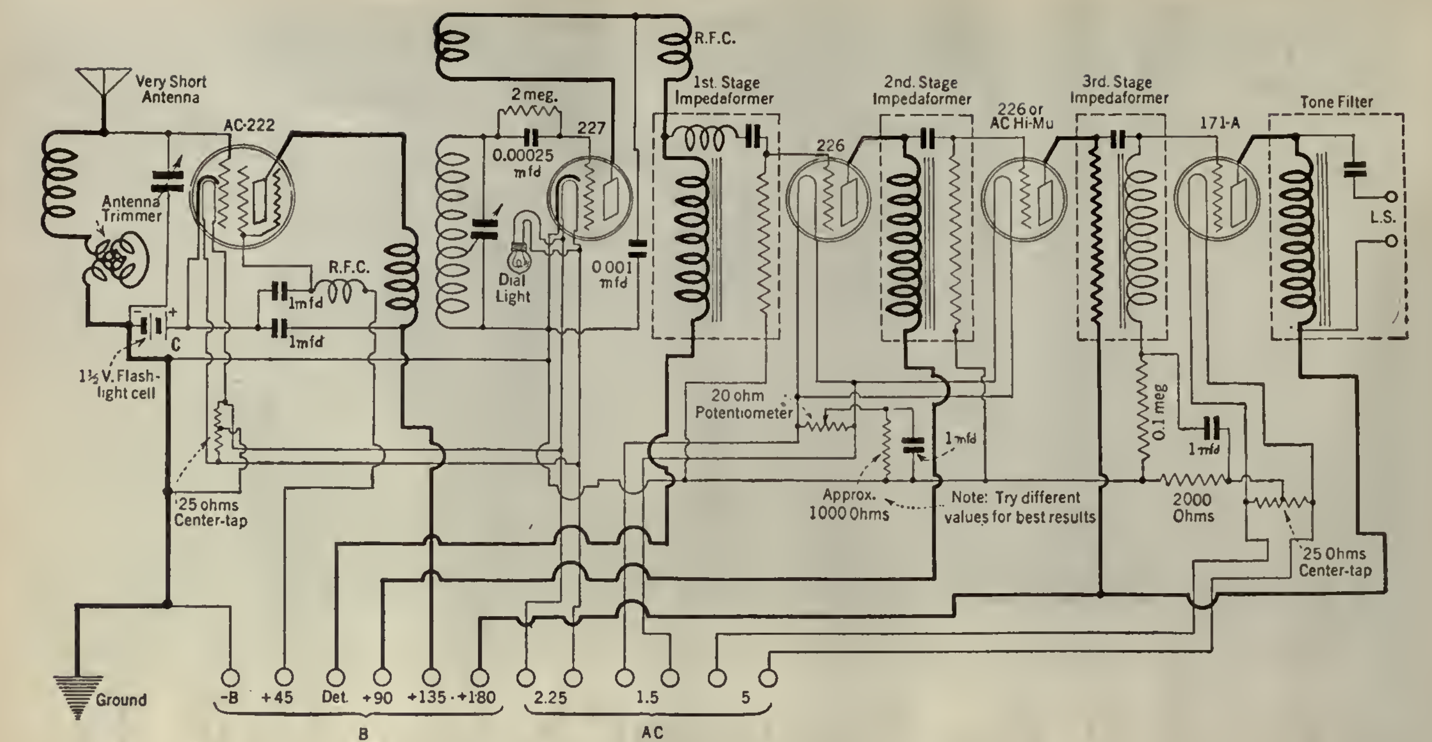


FIG. 1. THE CIRCUIT OF THE A. C. MODEL

better signal strength of dx stations, it has been found that the more conventional 0.00025-mfd. condenser with a 2-megohm leak results in more smooth and uniform regeneration over the entire broadcast band. When the 0.0001-mfd. condenser is used the set will not oscillate at the very upper end of the wavelength range.

The polarity of the primary connections to the r.f. transformer also has a noticeable effect at times on the smoothness of the regeneration. While generally best results are obtained with the plate lead of the 222 tube connected to the primary terminal nearest the front panel, such is not always the case. In some instances it makes no apparent difference which way these leads are connected, while in other instances the reversed connection gives best results.

NOTES ON THE AUDIO SYSTEM

THE audio system used in the original receiver, while capable of very satisfactory results, is not the only type that may be employed. Many inquiries have been received from readers who favored transformer or resistance coupling and wanted to know if one of the other forms of amplification could be employed with quite satisfactory results. The answer is decidedly "Yes." If a pair of high-grade audio transformers, such as the National, Amertran, Ferranti, etc., are employed, just as fine results are obtained with the use of one less tube. In the advent of such a change, the ⅘-ohm filament equalizer specified for the 5-tube set should be replaced by a 1-ohm resistor.

It has been found that with some of the sets made up by different constructors, it was necessary to ground the case of the tone filter to the A-minus lead. This same condition was also encountered in one transformer-coupled set, in which grounding the cases of both audio transformers, as well as that of the tone filter, proved worth while.

SOCKET POWER OPERATION

WHILE designed for use with a 6-volt storage A battery and a good 180 volt B-power unit, a.c. tubes may be used, if desired, for complete a.c. operation of the Screen-Grid Five receiver. In such event, the new a.c. type 222 tube, such as the CeCo, should be used in the r.f. stage. Alternating current has been used by some experiments directly on the filament of a standard d.c. type of 222 tube, but the results have never been any too satisfactory, due to the resulting 60-cycle modulation of the signal. The new a.c. 222 tube, however, completely overcomes such trouble, as it is of the heater type, similar to the UY-227.

The UY-227 works very well as the detector in conjunction with the a.c. 222 in the r.f. stage. In the first audio stages, either 227's or the 226's may be used. Some tube manufacturers are now making high-mu a.c. tubes of the 226 type, one of which will be quite worth while for use in the second stage. In the output stage the regular 171A with 5 volts a.c. on the filament is used.

The layout of the a.c. set is essentially the same as that of the d.c. model except for a few minor substitutions among some of the smaller parts. For the radio-frequency and the detector tubes, 5-prong sockets should be used in place of the 4-prong type. The two filament ballasts of the d.c. set are omitted. The two grid bias resistors, the power tube grid filter resistor and associated condenser, the two center-tapped resistors, the small potentiometer, the bypass condenser and the small 1½-volt biasing cell for the 222 tube are the special parts required for the a.c. receiver. The parts and connections are indicated in Fig. 1.

> *FREE BLUEPRINTS*
>
> *The interest in the d. c. model of the National Screen-Grid Five has been so great that blueprints of this receiver will be sent to all who write for them. Address requests to Mr. James Millen, care of RADIO BROADCAST*

Flexible No. 18 rubber covered wire should be used for making all the filament connections, which should be run in twisted pairs. The dial light is connected directly across the 2.25-volt a.c. supply. The leads to the dial light should be twisted together. While a center-tapped resistor may, if desired, be used across the 1½-volt filament line, it will be found in most cases that the use of a potentiometer, or other form of adjustable resistor for this work, will result in less a.c. hum from the finished receiver.

The average value of the resistor used for obtaining the grid biasing voltage for the first two audio stages is about 1000 ohms, but it may be found with some sets that a slightly higher value will give better results. Varying the plate voltage of the first a.f. stage is also something well worth trying.

The power unit for the operation of such a receiver may comprise either a standard high-grade 180-volt B unit and separate filament heating transformer, or else one of the special combination A-B units, such as the National No. 7180 A-B unit, in which the filament windings are part of the B-supply transformer. This later arrangement makes a compact and easily connected power supply.

A list of the additional parts necessary for a.c. operation is given on this page. Other makes of parts may be substituted if the set builder desires.

LIST OF ADDITIONAL PARTS FOR A.C. OPERATION

2 General Radio 5-prong sockets
2 25-ohm center-tapped resistors
1 2000-ohm resistor
1 1000-ohm resistor
1 .1-megohm resistor
3 single mountings
1 Carter midget 20-ohm potentiometer.
2 Tobe 1-mfd. condensers
1 1½ volt C Battery
1 CeCo a.c. 222 tube
1 CeCo N 27 tube
1 CeCo M 26 standard tube
1 CeCo AC Hi-Mu tube
1 Ceco J 71A tube

The accessories for a.c. operation are a standard 180-volt B-power unit, and a filament heating transformer.

New Apparatus

PRODUCTS of radio manufacturers whether new or old are always interesting to our readers. These pages, a feature of Radio Broadcast, *explain and illustrate products which have been selected for publication because of their special interest to our readers. This information is prepared by the Technical Staff and is in a form which we believe will be most useful. We have, wherever possible, suggested special uses for the device mentioned. It is of course not possible to include all the information about each device which is available. Each description bears a serial number and if you desire additional information direct from the manufacturer concerned, please address a letter to the Service Department,* Radio Broadcast, *Garden City, New York, referring to the serial numbers of the devices which interest you and we shall see that your request is promptly handled.*—The Editor.

A 12-Conductor Cable for A. C. Sets

X47

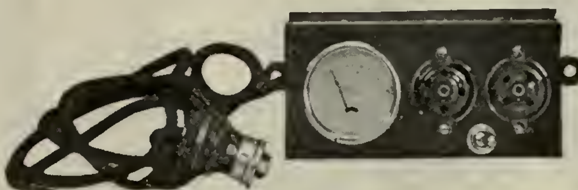
Device: Yaxley Cable, Type 612. A 12-conductor cable designed for use with a.c. receivers. The twelve conductors are arranged as follows:

1½V	No. 1—Red
	No. 2—Black
2½V	No. 3—Red, with Green Tracer
	No. 4—Black, with Green Tracer
5V	No. 5—Red, with Yellow Tracer
	No. 6—Black, with Yellow Tracer
B—	No. 7—Yellow
B+ Detector,	No. 8—Blue
B+ Intermediate,	No. 9—Slate
B+ Amplifier,	No. 10—Green
B+ Power,	No. 11—Brown
Spare,	No. 12—White

The plug terminals on the mounting plate are plainly numbered in white. The individual conductors in the cable are colored as is indicated above. In addition, each conductor is also numbered, 1, 2, or 3, etc., to correspond to the numbers of the plug terminals on the mounting plate. In this way it is a simple matter to make the proper connections. *Manufacturer:* Yaxley Manufacturing Company. *Price:* $5.00.

Application: This cable may be used in cases where the transformer supplying the filaments of the a.c. tubes is not located in the set, but with the B-power unit. In such a case it is, of course, necessary to use connecting wires between the set and the filament transformer as well as to provide leads for the B voltages. This requires a 12-conductor cable such as we have described.

YAXLEY CABLE



STERLING TUBE CHECKER

Resistors for B Supply

X 48

Device: Vitrohm Resistor Kit for use in B-power units. A set of eight separate resistors as follows: 1 750-ohm, 3 1500-ohm, 1 3000-ohm, 1 3500-ohm, 2 5000-ohm. Each resistor measures about 2 inches long. *Manufacturer:* Ward Leonard Electric Company. *Price:* $8.90.

Application: The resistors are of such a size and rating that they may be satisfactorily used as voltage-dividing resistors in B-power units delivering voltages up to 500 volts. The two circuits, Fig. 1, A and B, show how the resistors can be used in two B-power circuits, one delivering up to 135 volts and the other supplying 400 volts. The 135-volt circuit makes use of only four of the resistors. If the experimenter so desires he can make use of all eight units and obtain some additional B-voltage taps at intermediate voltages between 135 volts and 22 volts. As mentioned above these resistors are of such values that they can be applied to any ordinary B supply.

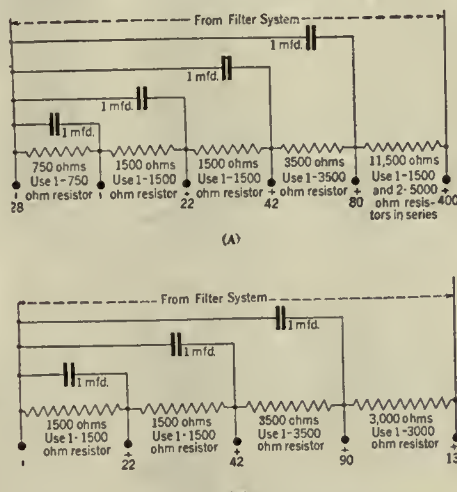


FIG. 1. B-SUPPLY RESISTOR BANKS

A Handy Tube Tester

X49

Device: Tube Checker. An easily operated, low priced, rugged instrument with which to check all types of tubes for short circuits between the elements, and to check the emission of a.c. tubes and 199 and 120 type tubes. To operate the unit the plug is connected to a 110-volt light socket and the tube to be tested is plugged into the tube socket on the tester. The meter immediately indicates any defect in the tube. *Manufacturer:* Sterling Manufacturing Company. *Price:* $13.50.

Application: This instrument is a convenient method for the radio dealer or service man to use when selling tubes to a customer, for it can be used to show that the tube being sold is in good condition. It will also be valuable in the repair department or in the hands of the service man.

Coils for Short-Wave Work

X 50

Device: Short-Wave Coils. A set of three coils to cover the band of wavelengths from 13 to 130 meters. Additional coils can be obtained to cover wavelengths up to 550 meters. The coils, illustrated in the photograph, are of the plug-in type, different ranges being covered by changing the secondary-tickler coil. The same primary is used for all wavelengths. The coils are wound with a large size of wire so as to give them considerable mechanical strength. The coil diameter is 2 inches. *Manufacturer:* Aero Products, Inc. *Price:* $12.50 for a set of three coils covering the band from 13 to 130 meters. Two additional coils, sold separately, may be used to reach up to the broadcast band. These coils are $4.00 each.

AERO SHORT-WAVE COILS

Application: The coils may be used in the construction of a short-wave receiver to receive code and short-wave broadcasting. The plug-in base and primary coil mounting are of the same dimensions as were used for previous types of Aero coils, so that either new or old coils may be used interchangeably in the same mounting.

A Way to Remedy R. F. Oscillation

X 51

Device: Phasatrol. A device designed for use in radio-frequency circuits to control oscillation. The unit is connected in the plate circuit of an r.f. amplifier tube and the adjusting screw is then turned until the circuit is stable over the entire broadcast band. *Manufacturer:* Electrad, Inc. *Price:* $2.75.

Application: The item to which we have here brought the reader's attention is not new, but some information regarding its use should be of interest to readers not acquainted with the device and to those not realizing that it may be applied to a wide variety of circuits. The performance of the unit depends, to some extent, upon the fact that if the plate load on a tube is made non-reactive (ordinarily its reactance is inductive) the tube cannot oscillate. Although the device does not give an exact "bridge" balance, it is much more simply adjusted than a bridge system, and can be readily applied to existing receivers. The device can be used to stabilize the intermediate-frequency amplifier of a super-heterodyne. It can also be used in such receivers as the Equamatic, the Bremer-Tully Counterphase, Roberts receivers, all tuned r.f. sets, etc., and its application to such circuits is fully covered in the circular supplied with it. Readers owning such receivers, or similar ones, which cannot be prevented from oscillating, can use a Phasatrol to overcome the difficulty.

THE PHASATROL

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on this page. Order by number only.

1. Filament Control—Problems of filament supply, voltage regulation, and effect on various circuits. Radiall Company.

2. Hard Rubber Panels—Characteristics and properties of hard rubber as used in radio, with suggestions on how to "work" it. B. F. Goodrich Rubber Company.

5. Carborundum in Radio—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. The Carborundum Company.

9. Volume Control—A leaflet showing circuits for distortionless control of volume. Central Radio Laboratories.

10. Variable Resistance—As used in various circuits. Central Radio Laboratories.

12. Distortion and What Causes It—Hook-ups of resistance-coupled amplifiers with standard circuits. Allen-Bradley Company.

15. B-Eliminator and Power Amplifier—Instructions for assembly and operation using Raytheon tube. General Radio Company.

15a. B-Eliminator and Power Amplifier—Instructions for assembly and operation using an R. C. A. rectifier. General Radio Company.

16. Variable Condensers—A description of the functions and characteristics of variable condensers with curves and specifications for their application to complete receivers. Allen D. Cardwell Manufacturing Company.

17. Bakelite—A description of various uses of bakelite in radio, its manufacture, and its properties. Bakelite Corporation.

46. Audio-Frequency Chokes—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. Samson Electric Company.

47. Radio-Frequency Chokes—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. Samson Electric Company.

48. Transformer and Impedance Data—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. Samson Electric Company.

49. Bypass Condensers—A description of the manufacture of bypass and filter condensers. Leslie F. Muter Company.

50. Audio Manual—Fifty questions which are often asked regarding audio amplification, and their answers. Amertran Sales Company, Incorporated.

52. Audio Quality—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. Silver-Marshall, Incorporated.

56. Variable Condensers—A bulletin giving an analysis of various condensers together with their characteristics. General Radio Company.

57. Filter Data—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. Electric Specialty Company.

70. Improving the Audio Amplifier—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. American Transformer Company.

72. Plate Supply System—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. Amertran Sales Company.

B1. Better Tuning—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. Bremer-Tully Manufacturing Company.

B3. Socket Power Device—A list of parts, diagrams, and templates for the construction and assembly of socket power devices. Jefferson Electric Manufacturing Company.

B4. Five-Tube Equamatic—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. Karas Electric Company.

85. Filter—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. The Abox Company.

B6. Short-Wave Receiver—A booklet containing data on a short-wave receiver as constructed for experimental purposes. The Allen D. Cardwell Manufacturing Corporation.

88. Super-Heterodyne Construction—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. The George W. Walker Company.

B9. Short-Wave Transmitter—Data and blue prints are given on the construction of a short-wave transmitter, together with operating instructions, methods of keying, and other pertinent data. Radio Engineering Laboratories.

90. Impedance Amplification—The theory and practice of a special type of dual-impedance audio amplification are given. Alden Manufacturing Company.

93. B-Socket Power—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. National Company, Incorporated.

101. Using Chokes—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. Samson Electric Company.

22. A Primer of Electricity—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. National Carbon Company.

23. Automatic Relay Connections—A data sheet showing how a relay may be used to control A and B circuits. Yaxley Manufacturing Company.

26. Dry Cells for Transmitters—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. Burgess Battery Company.

28. B Battery Life—Battery life curves with general curves on tube characteristics. Burgess Battery Company.

30. Tube Characteristics—A data sheet giving constants of tubes. C. E. Manufacturing Company.

32. Meters for Radio—A catalogue of meters used in radio, with diagrams. Burton-Rogers Company.

33. Switchboard and Portable Meters—A booklet giving dimensions, specifications, and shunts used with various meters. Burton-Rogers Company.

36. Charging A and B Batteries—Various ways of connecting up batteries for charging purposes. Westinghouse Union Battery Company.

37. Why Radio Is Better with Battery Power—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. National Carbon Company.

53. Tube Reactivator—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. The Sterling Manufacturing Company.

69. Vacuum Tubes—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. Radio Corporation of America.

87. Tube Tester—A complete description of how to build and how to operate a tube tester. Burton-Rogers Company.

92. Resistors for A. C. Operated Receivers—A booklet giving circuit suggestions for building a. c. operated receivers, together with a diagram of the circuit used with the new 400-milliampere rectifier tube. Carter Radio Company.

102. Radio Power Bulletins—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the BH or B rectifier tubes. Raytheon Manufacturing Company.

103. A. C. Tubes—The design and operating characteristics of a new a. c. tube. Five circuit diagrams show how to convert well-known circuits. Sovereign Electric & Manufacturing Company.

58. How to Select a Receiver—A commonsense booklet describing what a radio set is, and what you should expect from it, in language that any one can understand. Day-Fan Electric Company.

67. Weather for Radio—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. Taylor Instrument Companies.

73. Radio Simplified—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. Crosley Radio Corporation.

76. Radio Instruments—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. Jewell Electrical Instrument Company.

7B. Electrical Troubles—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. Burton Rogers Company.

95. Resistance Data—Successive bulletins regarding the use of resistors in various parts of the radio circuit. International Resistance Company.

96. Vacuum Tube Testing—A booklet giving pertinent data on how to test vacuum tubes with special reference to a tube testing unit. Jewell Electrical Instrument Company.

98. Copper Shielding—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. The Copper and Brass Research Association.

99. Radio Convenience Outlets—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set. Yaxley Manufacturing Company.

105. Coils—Excellent data on a radio-frequency coil with constructional information on six broadcast receivers, two short-wave receivers, and several transmitting circuits. Aero Products Company.

106. Audio Transformer—Data on a high-quality audio transformer with circuits for use. Also useful data on detector and amplifier tubes. Sangamo Electric Company.

108. Vacuum Tubes—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. Arcturus Radio Company.

110. Receiver Construction—Circuit diagram and constructional information for building a five-tube set using restricted field coils. Boonte Electric Company.

111. Storage Battery Care—Booklet describing the care and operation of the storage battery in the home. Marko Storage Battery Company.

112. Heavy-Duty Resistors—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. Ward Leonard Electric Company.

113. Cone Loud Speakers—Technical and practical information on electro-dynamic and permanent magnet type cone loud speakers. The Magnavox Company.

114. Tube Adapters—Concise information concerning simplified methods of including various power tubes in existing receivers. Alden Manufacturing Company.

115. What Set Shall I Build?—Descriptive matter, with illustrations, of fourteen popular receivers for the home constructor. Herbert H. Frost, Incorporated.

104. Oscillation Control with the "Phasatrol"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. Electrad, Incorporated.

116. Using a B Power Unit—A comprehensive booklet detailing the use of a B power unit. Tables of voltages—both B and C—are shown. There is a chapter on trouble-shooting. Modern Electric Mfg. Co.

11B. Radio Instruments, Circular "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. Weston Electrical Instrument Corporation.

120. The Research Worker—A monthly bulletin of interest to the home constructor. A typical feature article describes the construction of a special audio amplifier—Aerovox Wireless Corporation.

121. Filter Condensers—Some practical points on the manufacture and use of filter condensers. The difference between inductive and non-inductive condensers. Polymet Mfg. Corp.

122. Radio Tubes—Specifications and operating characteristics of vacuum tubes. Twenty-four pages. E. T. Cunningham, Inc.

123. B Supply Devices—Circuit diagrams, characteristics, and list of parts for nationally known power supply units. Electrad, Inc.

124. Power Amplifier and B Supply—A booklet giving several circuit arrangements and constructional information and a combined B supply and push-pull audio amplifier, the latter using 210 type tubes. Thordarson Electric Mfg. Co.

125. A. C. Tube Operation—A small but complete booklet describing a method of filament supply for a.c. tubes. Thordarson Electric Mfg. Co.

126. Micrometric Resistance—How to use resistances for: Sensitivity control; oscillation control; volume control; regeneration control; tone control; detector plate voltage control; resistance and impedance coupling; loud speaker control, etc. American Mechanical Laboratories.

127. Vitrohm News—A monthly bulletin dealing with the resistance problems of the home constructor and experimenter. Ward Leonard Electric Co.

128. Sangamo Condensers—A helpful table for converting capacities from microfarads to micromicrofarads. Sangamo Electric Co.

129. Tone—Some model audio hook-ups, with an explanation of the proper use of transformers and chokes. Sangamo Electric Co.

130. Screen-Grid Audio Amplification—Diagrams and constructional details for remodeling old audio amplifiers for operation with screen-grid tubes. Thordarson Electric Mfg. Co.

131. The Mershon Condenser—Two illustrated booklets giving the theory and uses of the electrolytic condenser. Amrad Corporation

132. The National Screen Grid Short-Wave Receiver—Constructional and operating data, with diagrams and photographs. James Millen.

133. The National Shield-Grid Five—A circuit diagram with constructional and operating notes on this receiver. James Millen.

134. Remler Service Bulletins—A regular service for the professional set builder, giving constructional data, blueprints, and hints on marketing. Gray & Danielson Mfg. Co.

135. The Radiobuilder—A periodic bulletin giving advance information, constructional and operating data on S-M products. Silver-Marshall, Inc.

136. Silver-Marshall Data Sheet No. 1—Building and operating instructions for the S-M 670-B and 670-ABC power units. Silver-Marshall, Inc.

137. Silver-Marshall Data Sheet No. 2—Illustrated building and operating data on the S-M 685 Public Address Unipac. Silver-Marshall Inc.

138. Silver-Marshall Data Sheet No. 3—How to build and operate the S-M four-tube, short-wave receiver and the S-M short-wave adapter. Silver-Marshall, Inc.

In sending the coupon below, make sure that your name and address are included and are plainly written.

USE THIS BOOKLET COUPON

Radio Broadcast Service Department
Radio Broadcast, *Garden City, N. Y.*

Please send me (at no expense) the following booklets indicated by numbers in the published list above:

....

....

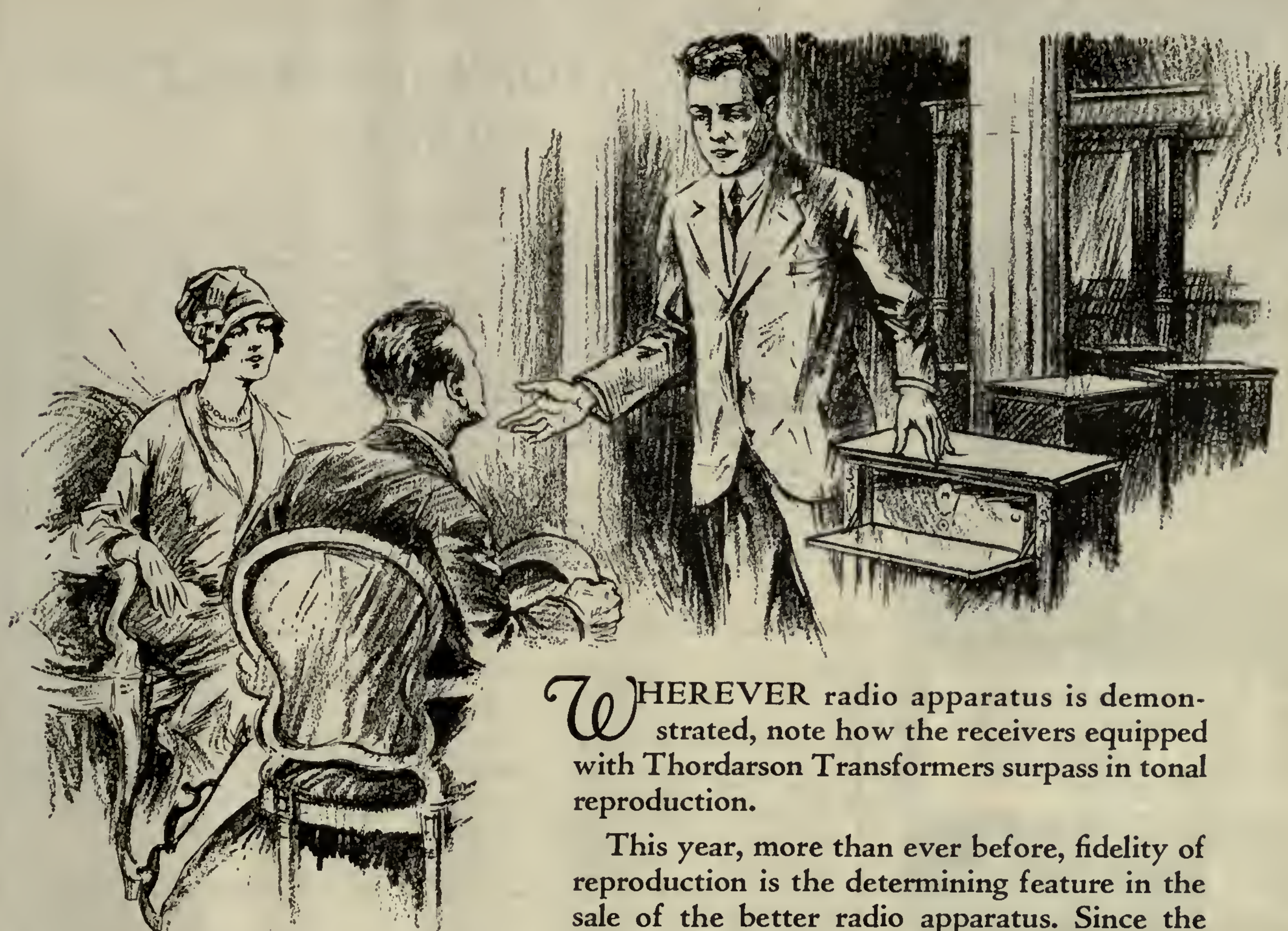
Name..

Address..
(*Number*) (*Street*)

....
(*City*) (*State*)

ORDER BY NUMBER ONLY

This coupon must accompany every request. RB 8-28



WHEREVER radio apparatus is demonstrated, note how the receivers equipped with Thordarson Transformers surpass in tonal reproduction.

This year, more than ever before, fidelity of reproduction is the determining feature in the sale of the better radio apparatus. Since the musical characteristics of a radio instrument depend to such a great extent on a wise selection of the audio and power supply transformers, it is significant that so many leading manufacturers have turned to Thordarson as the logical transformer source.

Equally significant is the fact that not once since Thordarson transformers became available to radio manufacturers has any other transformer approached the manufacturer popularity of Thordarson.

These quality instruments are Thordarson equipped:

ZENITH
SPARTON
Howard
PHILCO
Willard
Pfanstiehl
GILFILLAN
KENNEDY
MAGNAVOX
Neutrowound
Prest-O-Lite
RADIODYNE
Buckingham
MURDOCK
WALBERT
OZARKA
ARGUS
AUDIOLA
ERLA
and many others

THORDARSON

RADIO TRANSFORMERS

Supreme in musical performance

Thordarson transformers are universally available to custom set builders as well as manufacturers. Wherever radio parts are sold, there you will find a complete stock of Thordarson Audio and Power Supply apparatus. If you are building for real musical performance, insist on Thordarson Transformers.

THORDARSON ELECTRIC MANUFACTURING CO.
Transformer Specialists Since 1895
WORLD'S OLDEST AND LARGEST EXCLUSIVE TRANSFORMER MAKERS
Huron and Kingsbury Streets — Chicago, Ill. U.S.A. 3581

The *Radio Broadcast* LABORATORY INFORMATION SHEETS

THE RADIO BROADCAST Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4" x 6" filing cards, or in a notebook. The cards should be arranged in numerical order. In July, 1927, an index to all sheets appearing up to that time was printed. Last month we printed an index covering the sheets published from August, 1927, to May, 1928, inclusive.

All of the 1926 issues of RADIO BROADCAST are out of print. A complete set of sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Orders for the next set following can also be sent. Some readers have asked what provision is made to rectify possible errors in these sheets. In the unfortunate event that any serious errors do occur, a new Laboratory Sheet with the old number will appear.

—THE EDITOR.

No. 209 RADIO BROADCAST Laboratory Information Sheet August, 1928

Selectivity

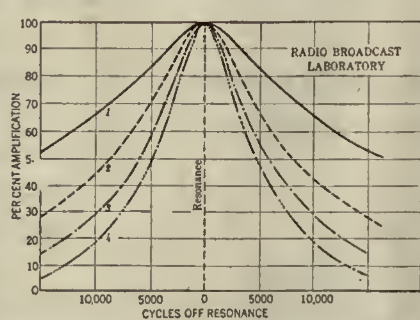
AS EFFECTED BY NUMBER OF R.F. STAGES

THE selectivity of a radio circuit depends upon many things, including the number of tuned stages, amount of coupling in the r.f. transformers, the characteristics of the tubes, the amount of regeneration in the circuit, the accuracy with which the individual circuits are tuned, etc. In this Sheet we will consider the effect on selectivity of increasing the number of tuned stages in a receiver. Future Laboratory Sheets will discuss the influence, on selectivity, of some of the other factors mentioned above.

Curve 1 represents the selectivity curve of a single r.f. stage. At a point 5,000 cycles off resonance the circuit gives 83 per cent. of the amplification at resonance; at 10,000 cycles off resonance the amplification has dropped to 65 per cent.

Now suppose we add more r.f. stages, with characteristics the same as that of the first stage. We then get the selective action indicated in Curve 2. If, at a certain point off resonance, the first stage reduced the amplification to 83 per cent., then the second stage would reduce the amplification to 83 per cent. of what came through the first stage. Referring to the curves, at a point 5,000 cycles off resonance, the various stages introduce a selective action as indicated below.

First stage = 83 per cent.
Second stage = 83 x 83 = 69 per cent.
Third stage = 83 x 83 x 83 = 57 per cent.
Fourth stage = 83 x 83 x 83 x 83 = 47 per cent.



This means that if we had a four-stage r.f. amplifier with these characteristics, that a signal 5,000 cycles off the resonance frequency to which the stages were tuned, would be amplified only 47 per cent. as much as a signal at the resonant frequency. Since a radio wave includes modulation frequencies up to 5,000 cycles off resonance, it is evident that such an r.f. amplifier would cause considerable side band suppression with consequent signal distortion.

No. 210 RADIO BROADCAST Laboratory Information Sheet August, 1928

Protecting the Rectifier Tube

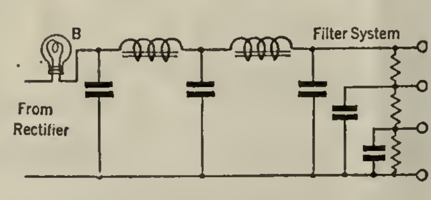
A PILOT LAMP TO INDICATE OVERLOAD

MOST of the rectifier tubes available at the present time will be severly injured if they are subjected to accidental short circuits or to excessive overload for any considerable period of time. In constructing power units it is therefore wise to place in the circuit some device which will serve to indicate any overload. Such an indicator is described in this Sheet and is applicable to power units of all types whether they use gaseous or filament type rectifiers.

The main precaution to be observed in operating rectifier tubes is that of avoiding an overload with respect to plate current. The shorting of the rectifier output, such as may occasionally occur due to the failure of some part of the apparatus (as by the breakdown of a filter condenser) will overload the filament and result in filament failure (in the case of filament type rectifiers) unless the current is turned off promptly.

To indicate an overload it is a good idea to connect a small lamp in series with the rectifier output as indicated at B in the circuit diagram on this Sheet. A small lamp such as is used as a dial light may be used for this purpose. Excessive brilliancy of this lamp will immediately indicate an overload, which can then be remedied before damage results.

In constructing power amplifiers and B supplies it is also a good idea to place a fuse in the primary side of the power transformer. This fuse will protect the transformer from damage in case its secondary is accidentally short circuited. The fuse should preferably be of the ordinary plug type with a rating of about three amperes. Only one fuse need be used, connected in series with one side of the line and the transformer.



Letters from Readers

What a Vacuum Tube Can't Do

ANOTHER good fiction—and this one countenanced by RADIO BROADCAST—has received its death blow at the stern hands of reality. Witness this letter:

To the Editor:

With no thought of destroying the sentiment of the interesting and informative article, "The Haven of a Sea-going Audion," in the June issue of RADIO BROADCAST, I would like to protest the author's theory that the audion "may have started in the Atlantic, bobbed through the Canal, crossed the Pacific, etc."

If he were to visit the Canal (I presume he means the Panama Canal) he would find that it would be impossible for any floating object to drift through from one ocean to the other. The level of Gatun Lake is eighty odd feet above the sea. The water used in raising and lowering ships in the locks as they enter or leave the Canal comes from the lake, and flows to the sea through the locks at either end of the Canal. The frail glass bulb would have a poor chance reaching the lake against such a counter current thus created.

This is the second time in the last two or three years I have noticed the same mistake in the press. The general public is obsessed with the mistaken notion of things floating through the Panama Canal from one ocean to the other. Don't you think a correct impression ought to be made?

R. S. FULTON,
Radio Operator, S.S. Hochelega

Greenwich Mean or Civil Time?

THE list of short-wave transmissions which appeared in the May number of RADIO BROADCAST has brought forth several interesting letters in regard to the confusion existing about the meaning of the terms "Greenwich Mean Time" (G. M. T.) and "Greenwich Civil Time" (G. C. T.) The list of short-wave stations was reprinted from *Wireless World*, London, England, and retained the time designations of the English magazine. RADIO BROADCAST also printed in the May number (page 53) a conversion table for G. C. T., G. M. T., and 75th meridian time (E. S. T.) That this conversion table was in error is shown by the following letter from C. S. Freeman, Superintendent of the U. S. Naval Observatory in Washington D. C.

To the Editor:

It is unfortunate that the usage of the terms "Greenwich Mean Time" and "Greenwich Civil Time" is not the same in the United States and foreign countries. Originally the term "Mean Time" was universally used to refer to a day beginning at noon, but on January 1, 1925, an international agreement went into effect by which the use of such time was discontinued, and all solar time computed beginning from midnight. In the United States this new time was designated as "Civil Time," but foreign countries retained the designation "Mean Time." Both these designations therefore now refer to the same kind of time.

Your table (page 53) should read:

G. C. T. or G. M. T. Hours	75TH MERIDIAN (E. S. T.)
0	7:00 P. M.
6	1:00 A. M.
12	7:00 A. M.
14	9:00 A. M.
18	1:00 P. M.
22	5:00 P. M.
24	7:00 P. M.

It should be noted, however, that the expression "24 hours" is not in use, "0 hours" being in use instead. In your table all the 75th meridian times are marked "P. M.," although the second, third, and fourth should be marked "A. M."

(*Continued on page 233*)

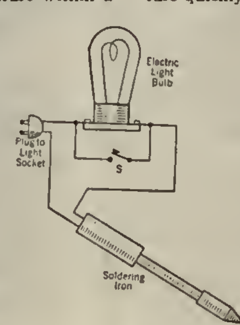
No. 211 Radio Broadcast Laboratory Information Sheet **August, 1928**

Soldering Irons

HOW TO CARE FOR THEM

PRACTICALLY all commercial soldering irons are designed to heat rapidly so that they will be brought to an operating temperature within a short time after they are connected to the line. Unfortunately, however, if they are left connected to the line after they have reached an operating temperature they become too hot for satisfactory work, the tip blackens very quickly, becomes pitted, and in a comparatively short while the iron requires a new soldering tip. All this trouble can be easily overcome, and the manner in which it is done in the Laboratory may be of interest to readers.

The arrangement used in the Laboratory is indicated in the diagram. The soldering iron is connected in series with an ordinary electric light bulb across the power line. A short-circuiting switch, S, is provided across the bulb. The procedure when some soldering is to be done is to push the plug in to the light socket and close switch, S. With the switch, S, closed the iron is then connected directly across the line and reaches a satisfactory operating temperature quickly. When this temperature is reached the switch is reopened so that the electric light is in series with the iron. The size of electric light used is such that the iron is maintained at the correct temperature and does not overheat even though the power is left on for hours without using the iron. If an arrangement such as this is used the tip of the iron will remain tinned for a long time, and a better soldering job can be done.



The wattage of the electric light bulb that is used depends upon the soldering iron. The particular irons used in the Laboratory work best with a 75-watt lamp. The switch, S, may be almost any type although it is a good idea to use some kind of enclosed switch designed for use on 110-volt lighting circuits.

No. 212 Radio Broadcast Laboratory Information Sheet **August, 1928**

Equalizers

WHY THEY ARE USED

IN TRANSMITTING outside events (programs that do not originate in the studio) broadcasting stations have to make use of wire lines to connect the control room of the station with the microphone and amplifier apparatus located at the point at which the program originates. These wire lines must transmit with equal efficiency a band of frequencies from about 100 cycles to about 5,000 cycles. In order to give a wire line such a characteristic it is necessary that it be "equalized" so that the transmission efficiency will be equal over the entire band of audio frequencies. The device used to give a line such a characteristic is termed an "equalizer" and its action will be explained in this sheet in conjunction with the diagram on Sheet No. 213.

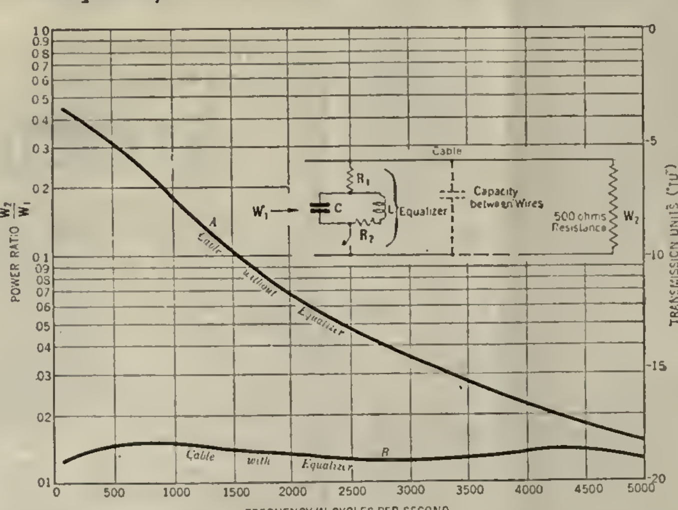
The frequency characteristic of a seven-mile length of cable is indicated in curve A on Sheet No. 213. This characteristic shows that the cable transmits the low frequencies much better than the high frequencies, due to the fact that there is considerable capacity between the two wires that form the pair of cables and this capacity tends to bypass the higher frequencies. Equalization is accomplished by introducing into the circuit a device that will lower the transmission efficiency at low frequencies to a value equal to the efficiency at high frequencies; this is the function of the equalizer.

The equalizer consists of a network of resistances, capacities, and inductances of values such that they introduce a considerable loss at low frequencies where the transmission efficiency of the cable is high and practically no loss in efficiency at the high frequencies where the transmission efficiency is low. The result is that the efficiency of the entire system is reduced to approximately the efficiency of the cable at the highest frequencies to be transmitted.

The curve B shows the characteristics of the cable with the equalizer in use; the frequency characteristic is sensibly flat from 100 cycles to 5,000 cycles. As was mentioned above this betterment in the frequency characteristic is obtained at a considerable reduction in overall efficiency. The low efficiency is then compensated by connecting repeaters (power amplifiers) in the circuit to raise the power level of the entire system. The broadcasting circuit connecting New York with Chicago contains about eight repeater points. Power amplifiers are located at these points and function to boost the power in the line to overcome the loss in the cable. As a result we frequently find cases where the final amount of power at the receiving end is considerably greater than the power originally introduced in the line at the transmitting end.

No. 213 Radio Broadcast Laboratory Information Sheet **August, 1928**

Frequency Characteristic of a Seven-Mile Cable



Letters from Readers

(*Continued from page 231*)

From this letter it appears that the Greenwich Mean Time used in the list reprinted from the *Wireless World* is the continental equivalent of the United States Greenwich Civil Time. This fact explains the following letter from a Toronto, Canada, reader of the magazine; .

To the Editor:

May I take the liberty of pointing out an error in the May RADIO BROADCAST? At the top of the list on page 44 of the May number you state that "all the times are given in Greenwich Mean Time (G. M. T.) "—nevertheless the times *actually were given in G. C. T.* (Greenwich Civil Time). Also note that five o'clock P. M. London time, which is noon E. S. T., certainly is *not* 5:00 P. M. G. M. T.

For your information I would state the following:

1. The term "Greenwich Time" is ambiguous and doesn't mean anything as far as we are concerned.
2. G. C. T. (which is the same as London time) *is* five hours ahead of E. S. T.
3. G. M. T. or Greenwich Mean Time is the mean day, astronomical or solar day, commencing at noon of the civil day of the same date.

This was shown at the bottom of page 53, only there was another error here—all the times under "75th Meridian" were "P. M."

The corrected column should read as follows: (page 53)

G. C. T.	G. M. T.	75TH MERIDIAN
00	12	07 P. M.
06	18	01 A. M.
12	00	07 A. M.
14	02	09 A. M.
18	06	1 P. M.
22	10	5 P. M.
24	12	7 P. M.

It is apparent that you listed the right times but called them by the wrong name and also that the two tables (pp. 44 and 52) do not conflict.

It is amazing how universal this error of confusing G. C. T. and G. M. T. has been. Apparently people thought G. M. T. meant "Greenwich Meridian Time."

I am a ship operator and I certainly know that 10 P. M. E. S. T. is 0300 G. C. T. I also know that G5SW transmits phone from 1930 G. C. T., or 2:30 P. M. E. S. T., onwards.

If the U. S. Naval Observatory is correct, the second column of this conversion table refers to the *old* Greenwich Mean Time, which is no longer used. It does not yet seem clear to us, however, whether or not there is any recognized method of time computation employed at present here or abroad which begins its day at noon.

An Old-Timer Recalls

To the Editor:

The picture of the Wireless Room on the *SS Bermuda* in your June issue [page 71] came to me like a voice from the past. The gear was that of the Marconi Co. of London, a firm I worked for from 1915 to 1927.

On looking over the gear I noticed a slight error: the ½-kw. quenched spark transmitter should read ¼-kw. quenched spark transmitter. It is a 1925 model originally intended for lifeboats but radiates up to 7 amps. and may be tuned to 300, 450, 600, and 800 meters. It is identical with the auxiliary transmitter on my own ship. Our main installation is an R. C. A. c. w. and i. c. w. transmitter with a range of waves from 600 to 2500 meters.

WILLIAM I. BOOBYER
Radio Operator, S.S. Beaconstreet

A Correction in the July Number

In the article "How to Build a Beat-frequency Oscillator", by G. F. Lampkin, in the July number of RADIO BROADCAST, an error occurred in the picture at the bottom of page 157. The two coils marked 40T should be marked 55T, and the two marked 55T marked 40T. The coil diagram in Fig. 1 is correct in these dimensions.

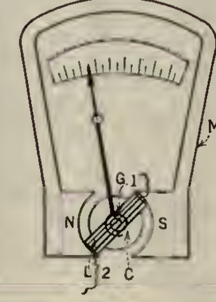
No. 214 Radio Broadcast Laboratory Information Sheet **August, 1928**

Measuring Instruments

HOW THEY WORK

THE drawing on this sheet shows in simple form the arrangement of the parts in an electrical measuring instrument such as might be used to measure the currents and voltages in a radio receiver. The instrument consists essentially of a very strong permanent magnet, M, a cylindrical soft iron core, C, a moving coil, L, the ends of which connect to the leads 1 and 2 which would be connected to the binding posts on the instrument. The space between the poles of the magnet, marked N and S, and the iron core, C, is made quite small so that an intense magnetic field will exist in the air space between the core and the pole pieces. The coil, L, is free to move in this gap. To the coil is fastened a small spring, G, and a pointer which is generally made of aluminum so that it will be very light in weight. The coil is pivoted at its center on jeweled bearings and the spring is adjusted so that with no current flowing through the instrument the pointer rests at zero on the scale. When current passes through the coil, it moves on its pivots. This motion is opposed by the spring and for each value of current there is some position of the coil at which the turning force produced by the current is exactly balanced by the force due to the spring; the pointer therefore comes to rest at a position on the scale corresponding to the point at which these two forces balance. The scale can be marked off in values so as to indicate by its position on the scale the amount of current flowing through the instrument.

With strong magnets, delicate parts, and accurate workmanship, instruments can be built which take only a very small fraction of an ampere to move the pointer over its entire range; the scale may be calibrated in thousandths of an ampere, or milliamperes; the instrument is then known as a milliammeter.



No. 215 Radio Broadcast Laboratory Information Sheet **August, 1928**

The Hi-Q Six

THE PARTS USED

THE circuit diagram of the Hi-Q Six, the 1928 model of the kit receiver produced by the Hammarlund-Roberts Corporation, is published on Laboratory Sheet No. 216. On this Sheet we give some details regarding the circuit and parts used so that readers who are keeping a file of these sheets may have on hand for ready reference the data on this kit. Other sheets to follow will give information on other popular kits.

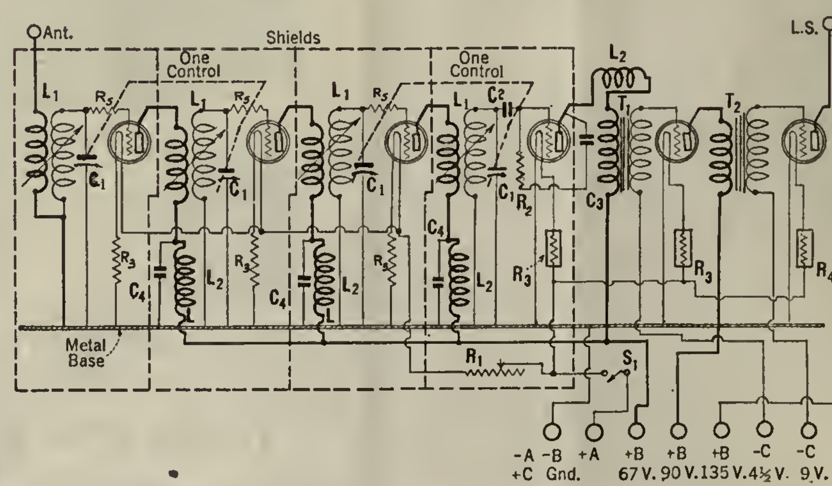
The circuit consists of three stages of r.f. amplification, followed by a non-regenerative detector and a two-stage transformer-coupled audio amplifier. The r.f. coils are arranged so that the coupling between the primary and secondary is varied automatically as the receiver is tuned. This feature helps to make the receiver perform equally well over the entire broadcast band. The first two tuning condensers are ganged to one tuning control and the other two condensers are ganged to the other control on the drum dial. Volume control is accomplished by means of a rheostat in the filament leads of the r.f. tubes. All of the r.f. stages are shielded.

The following parts were specified for the official kit; the notation in this list refers to the diagram on the following Laboratory Sheet.

T_1—Samson Symphonic Transformer. T_2—Samson Type HW-A3 Transformer (3–1 Ratio). C_1—4 Hammarlund 0.0005-Mfd. Midline Condensers. L_1—4 Hammarlund "Hi-Q" Six Auto-Couple Coils. L_2—4 Hammarlund Type RFC-85 Radio-Frequency Chokes. C_2—Sangamo 0.00025-Mfd. Mica Fixed Condenser. C_3—Sangamo 0.001-Mfd. Mica Fixed Condenser. R_1—Carter 1R-6 "Imp" Rheostat, 6 Ohms. S_1—Carter "Imp" Battery Switch. R_2—Durham Metallized Resistor, 2 Megohms. C_4—3 Parvolt 0.5-Mfd. Series A Condenser. R_3—4 Amperites No. 1-A. R_4—Amperite No. 112. R_5—3 500-ohm grid resistors. Hammarlund illuminated Drum Dial. 1 Pr. of Sangamo Grid Leak Clips. 6 Benjamin No. 9040 Sockets. 3 Eby Engraved Binding Posts. 1 Yaxley No. 660 Cable Connector and Cable. 1 Hammarlund Roberts "Hi-Q" Six Foundation Unit (containing drilled and engraved Westinghouse Bakelite Micarta panel, completely finished Van Doorn steel chassis, four complete heavy aluminum shields, extension shafts, screws, cams, rocker arms, wire, nuts, and all special hardware required to complete receiver).

No. 216 Radio Broadcast Laboratory Information Sheet **August, 1928**

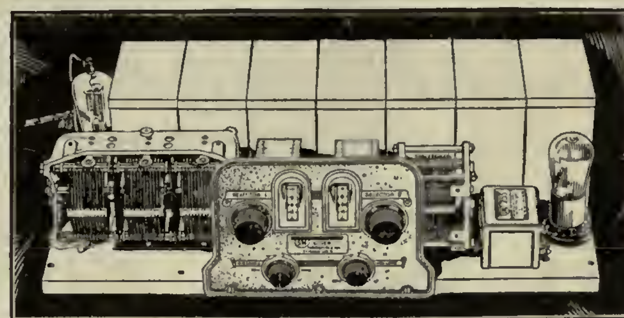
The Circuit of the Hi-Q Six



SM

THE NINE TUBE SCREEN GRID *Laboratory Receiver!*

Nine Tubes with Screen Grid Efficiency!



THREE stages of screen grid radio-frequency amplification, a screen grid first detector, two stages of 65 kc. intermediate screen grid I.F. amplification, and a super-powered second detector—all copper shielded—working into an audio stage using the new Clough system—no wonder the 1929 Laboratory receiver spins rings around the best of superheterodynes!

And all of this tremendous amplification, with selectivity that makes stations literally snap in and snap out, is under the control of two vernier drum dials, and a "volume" and a "sensitivity" knob. No wonder it's easy to bring in stations from Maine to Florida, Texas, California, and Canada all in an evening. No wonder a log of a hundred stations can be piled up with this ultra-selective, extraordinarily-sensitive screen-grid super that has outperformed every other superheterodyne tested against it!

For the fan who wants real "super" results without squeals and station repeats clogging up his dials, the Laboratory Super is *the* set. Just imagine a super that can be tuned from one end of the dials to the other right in Chicago without a single local station repeating, and yet be able to use a 65 kc. intermediate frequency with all the tremendous amplification this frequency, plus screen-grid tubes, gives. No wonder the new Laboratory Receiver is the set you've been looking for—a set so sensitive that you can out-demonstrate any other super with it at any time at all. And it has the ultra-fine tone that can be gotten only from the new S-M audio transformers and a stage of external light socket, push-pull 210 or 250 Unipac amplification, the highest powered, finest toned amplification money can buy!

If you've built lots of supers, and know what real results are, this set will give you a new thrill for distance, selectivity, tone.

Despite its absolutely startling performance, the parts, mostly of S-M manufacture with all that this implies, cost but $95.20 complete, less Unipac amplifier which is not absolutely essential. And the overwhelmingly superior results that the Laboratory Super will give, no matter what you compare it with, make it outstandingly *the finest superheterodyne money can buy.*

UNIPAC POWER AMPLIFIERS

Single Stage Unipac Amplifier

Either of two S-M single stage power amplifiers replaces B batteries on any receiver and adds a stage of super-power amplification. Type 681-210, the most powerful amplifier made, uses 2-UX210 or UX250 power tubes in push-pull, two UX281 rectifiers, and a UX874 regulator tube. It supplies 45, 90, and 135 volts B to the radio receiver. A lower-powered unit is the 681-250, using only one UX210 or UX250 amplifier tube, but identical with the 681-210 in other respects. Price, 681-210 WIRED push-pull Unipac $102.00; or 681-210 KIT, $87.00. Both are ideal for the Laboratory super. Price, 681-250 WIRED Unipac $96.50; or 681-250 KIT, $81.50.

Two Stage Unipac Amplifier

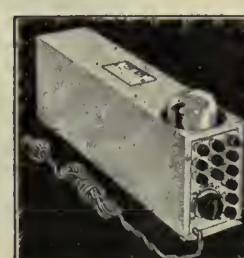
Two complete two stage super-power Unipac Amplifiers, for amplification of radio set detector output or phonograph record pickup are the finest and most powerful of their types. Type 682-210 uses one UX226 first stage tube, two UX210 or UX250 super-power tubes in a push-pull second stage, two UX281 rectifiers, and a UX874 regular tube. It supplies two stages of power amplification and 45, 90, and 135 volts B power for a receiver, and A.C filament power too. Type 681-250 is the same Unipac except that it uses only one UX210 or UX250 tube in the last stage. 682-210 WIRED push-pull Unipac lists at $117.00; or 682-210 KIT at $102.00. The 682-250 WIRED Unipac lists at $111.50; or 682-250 KIT at $96.50 ready to assemble.

Public Address Unipac

For coverage of crowds of 1,000 to 10,000 people, indoors or outdoors, with one to twelve loud-speakers, the 685 Public Address Unipac is the only light-socket amplifier now available. It uses one UY227, one UX226, one UX250, and two UX281 rectifiers in three stages for microphone, radio, or record pick-up amplification. It is the ideal self-contained, portable or permanent amplifier for conventions, theatres, churches, etc. Price 685 WIRED Unipac, $160.00; or 685 KIT, ready to assemble, $125.00.

MEDIUM AND HIGH VOLTAGE POWER SUPPLIES

B and ABC Power Units for Radio Sets



S-M 670B Reservoir Power Unit has five different B voltages, of 22, 90, 135, and 180 volts fixed, and one variable voltage ranging from 22 to 90 volts. It will deliver up to 60 M.A. to operate any standard receiver, and is specifically recommended for S-M receivers. Type 670ABC is the same unit with 1½, 2¼ and 5 volt A.C. filament supply added, and is a complete ABC power plant for any A.C. tube equipped receiver. Both use one UX280 rectifier. Price, 670B, WIRED, $43.50 or in kit form $40.50. Price 670ABC power supply WIRED, $46.00, or, in kit form, $43.00.

675ABC High Voltage Power Unit

Type 675 power unit is a high voltage power supply delivering 450 volts maximum. It is provided with an adapter which allows a UX210 or UX250 super-power tube to be used in the last stage of any receiver at all, to which the 675ABC supplies 22 fixed, 22 to 90 variable, and 90, 135, and 450 volts B power, as well as A and C power for the power tube, and 1½ and 2¼ volts A.C. for A.C. tube filaments if used. It is the biggest power unit value ever offered, and costs but $58.00 WIRED, or $54.00 in kit form, less one UX281 ectifier tube.

676 Dynamic Speaker Amplifier

This is a single stage power amplifier especially for use as a third stage, after any radio set, to boost volume and tone to give extra fine results with standard dynamic loud speakers. It uses one UX281 rectifier and one UX250 super-power amplifier, and has binding posts for receiver output connections, loud-speaker cord tips, and also for the dynamic speaker field. The 675 Amplifier operates any dynamic speakers having a 90 to 120 volt DC field, to which it supplies necessary power. Added to any set equipped with a dynamic speaker, it will provide a marvelous improvement in tone and volume. Price, 676 WIRED, $55.00; or 676 in KIT form, $49.00.

We carry for your convenience a complete line of S-M Radio Parts and Kits, including all the big new headliners for immediate shipment: 720 Screen Grid Six Kit, $72.50; 720 Custom-Built Receiver, $102.00; 710 Sargent-Rayment Kit, $120.00; 740 Coast-to-Coast Four Kit, $51.00; 730 Round-the-World Four Kit, $51.00; Complete Parts for 9-tube 1929 Laboratory Receiver $95.20. Any of these can be shipped at once, as well as the new Unipacs, power supplies, audio transformers, and other parts. Our new catalog will be a revelation to you—use the coupon and get it now! LIBERAL DISCOUNTS TO THE TRADE.

SETBUILDERS SUPPLY CO. ROMBERG BUILDING Madison & Market Sts. *Chicago*

Setbuilders Supply Co.
Romberg Bldg., Madison & Market Sts.,
Chicago, Ill.

Send me at once, free, your new catalog listing S-M and other radio parts, cabinets, consoles, and accessories of highest quality.

Name.......................................

Address.......................................

City....................State....................

RADIO BROADCAST

WILLIS KINGSLEY WING, Editor

SEPTEMBER, 1928 | KEITH HENNEY, Director of the Laboratory | EDGAR H. FELIX, Contributing Editor | Vol. XIII. No. 5

CONTENTS

The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

AMONG OTHER THINGS. . .

FOR a long time, readers of RADIO BROADCAST have been confused in buying the magazine on the newsstands because the magazine arrives on the newsstands on the 15th of the month and is dated the month following. That is, this issue, which is dated September, is on sale August 15th. In order to avoid confusion, beginning with the October RADIO BROADCAST each issue will be on sale on the first of the month. Look for your October issue on the first of October.

AT NO time since RADIO BROADCAST first appeared, which was in May, 1922, have so many letters of praise trooped into the editorial office. A great many of our readers are good enough to write us, telling exactly what they like in the magazine, and why. "Strays from the Laboratory," "Radio Broadcast's Home Study Sheets," and the "Service Data Sheets on Manufactured Receivers" are sharing honors at present. The "Home Study Sheets," the newest addition to the magazine, have been prepared because we have felt for a long time that radio readers wanted guidance in making their own home experiments. These "Home Study Sheets" are prepared by Keith Henney, director of the Laboratory. Both the author and the editor will be pleased to hear from readers who have suggestions on how the "Sheets" can be made more valuable to them.

IN 1925, when Carl Dreher was induced to begin preparing his department, "As the Broadcaster Sees It," the broadcasting art was very different from what we find it to-day. Since that time, more than 170,000 words dealing with broadcasting—both from the engineering and aesthetic point of view—have appeared under that department heading. The newest development of interest to the engineer and others associated with broadcasting and its problems is the talking movie. Beginning with October, Mr. Dreher's department "As the Broadcaster Sees It," will branch out. In addition to the material on broadcasting, which we are assured is widely useful, Mr. Dreher will treat of talking movies and in later issues of other fields closely related.

MANY of our amateur friends have hailed with delight the first article in the series of special short-wave contributions by Robert S. Kruse, formerly technical editor of *QST*. In the August RADIO BROADCAST, Mr. Kruse's first article appeared, dealing with the general aspects of 5-meter transmission. For our October number, Mr. Kruse expects to describe the construction and operation of an efficient and inexpensive battery-operated transmitter.

THE radio service man has found that a few simple instruments will make his task in the field much simpler. Many service men wrote us, praising Mr. Messenger's article in the July issue which described his set tester. On page 273 of this issue, a simpler unit is described which is useful for service men and those who would like to own a compact tester for general home experimental service.

WE APOLOGIZE for an error of our draftsman which we allowed to escape us in Fig. 2, page 218, RADIO BROADCAST for August in the article describing an r.f. stage for any set. The diagram will be correct if the reader removes the short vertical line which—now—short-circuits the A-battery.

—WILLIS KINGSLEY WING.

DOUBLEDAY, DORAN & COMPANY, INC., Garden City, New York

MAGAZINES
COUNTRY LIFE
WORLD'S WORK
GARDEN & HOME BUILDER
RADIO BROADCAST
SHORT STORIES
EDUCATIONAL REVIEW
LE PETIT JOURNAL
EL ECO
FRONTIER STORIES
WEST
THE AMERICAN SKETCH

BOOK SHOPS (Books of all Publishers)
NEW YORK: LORD & TAYLOR; JAMES MCCREERY & COMPANY; PENNSYLVANIA TERMINAL AND 166 WEST 32ND ST.; 848 MADISON AVE. AND 51 EAST 44TH STREET; 420 AND 526 AND 819 LEXINGTON AVENUE; GRAND CENTRAL TERMINAL AND 38 WALL STREET
CHICAGO: 75 EAST ADAMS STREET
ST. LOUIS: 223 N. 8TH ST. AND 4914 MARYLAND AVE.
KANSAS CITY: 920 GRAND AVE. AND 206 WEST 47TH ST.
CLEVELAND: HIGBEE COMPANY
SPRINGFIELD, MASS: MEEKINS, PACKARD & WHEAT

OFFICES
GARDEN CITY, N. Y.
NEW YORK: 244 MADISON AVENUE
BOSTON: PARK SQUARE BUILDING
CHICAGO: PEOPLES GAS BUILDING
SANTA BARBARA, CAL.
LONDON: WM. HEINEMANN, LTD.
TORONTO: DOUBLEDAY, DORAN & GUNDY, LTD.

OFFICERS
F. N. DOUBLEDAY, *Chairman of the Board*
NELSON DOUBLEDAY, *President*
GEORGE H. DORAN, *Vice-President*
S. A. EVERITT, *Vice-President*
RUSSELL DOUBLEDAY, *Secretary*
JOHN J. HESSIAN, *Treasurer*
LILLIAN A. COMSTOCK, *Asst't Secretary*
L. J. MCNAUGHTON, *Asst't Treasurer*

TERMS: $4.00 a year; single copies 35 cents.

HEADQUARTERS

for

A.C. SETS, KITS, PARTS, CONSOLES, DYNAMIC SPEAKERS . . . *and all*

S. M. PRODUCTS

Dealers and Set Builders should have our big up-to-the-minute book of values. All popular nationally known products—A.C. Sets, Kits, Parts, Consoles, Accessories. Biggest stock of parts.

Prices that mean real savings. COMPLETE stock of S. M. Products always on hand. Prompt delivery.

FREE

Send today for our Catalog. Lists everything in radio. Standard quality at the right price.

WESTERN RADIO MFG. CO.

"The Big Friendly Radio House"

128 W. Lake Street *Dept. SM 9* Chicago, Ill.

England Tackles the Multiplex Channel Problem

The simultaneous transmission of two high-speed telegraphic services and one telephone service over the same wavelength was recently demonstrated with this apparatus at the English Beam Station at Bridgewater. The demonstration, which was made in the presence of David Sarnoff, Vice-President of the Radio Corporation of America, was conducted between stations at Bridgewater, England (receiving), and Montreal, Canada (transmitting). Mr. G. A. Mathieu, who collaborated with Senatore Marconi in designing the system, is shown speaking into the telephone. It is claimed that this apparatus diminishes fading to a great extent, and thus gives constant volume of speech and signals. The engineering details of the system employed are not available at present.

A FILTER THAT SAVES 5 KILOCYCLES

This picture shows part of the speech input, modulating, filter and amplifying apparatus at the Rocky Point station of the Radio Corporation of America, where radiotelephonic transmission to Europe is carried on. The filter suppresses the carrier wave and one of the side-bands, thus halving the width of the channel necessary for transmission

Can We Multiplex Our Radio Channels?

By Albert F. Murray

THE solution of the problem of broadcast congestion is perhaps the most pressing of the needs of the broadcast listener to-day, and many people seem only too willing to believe that the solution will come, mysteriously, from some new invention. And so, when Dr. Lee DeForest some time ago made the statement that some 500,000 radiotelegraph stations could be disposed on the short-wave channels from 10 to 200 meters by means of a system of "double modulation," the press and general public believed that the long expected solution of the broadcasting problem was solved, and "double modulation" would soon multiplex all radio channels.

Mr. Murray considers the multiplexing of radio channels by means of "double modulation" from a technical and practical angle, shows how the system works, exactly what advantages may be realized from it, and what defects have kept it from being used so far. A method of multiplying channels—that of "single side-band" transmission—is also examined in a similar way. It is this second method which Mr. Murray considers most possible, its present practicality being limited by the need of skilful operation and precision instruments.

—The Editor.

THE progress of radio in the past has been so rapid, due to scientific genius and manufacturing skill, that a large part of the American public is now in the frame of mind in which it believes that almost anything is possible in the way of future developments. This attitude is held not only by the lay enthusiast for radio, but by some serious experimenters and technically minded men. New developments are expected to be realized almost by magic, and technical problems of the most difficult nature immediately solved by some new product of the inventor's skill. So it is that whenever some advance is made in radio, the press and the public immediately greet it as the herald of a new radio Utopia, without consideration of what technical, practical, or manufacturing obstacles are in the way.

We can understand then, in view of this attitude, the great stir of interest which some time ago was occasioned by press reports in which a well-known radio engineer outlined a "double tuning" system which was said would multiply each of the present radio channels by 100, thus making room for all those who are clamoring for space in the crowded ether. Concurrently, the question of finding space in the short-wave bands for the radio traffic of many corporations and private enterprises engaged the attention of the Federal Radio Commission. The natural result is that many of the radio public are now asking, "Is there really anything in these new radio systems?"

Regarding the proposed "double tuning" system, suppose we consider these questions: Is it a new or novel system? Will it multiply the existing radio channels? Are there good chances of this system being used in our country? How can more radio channels be made available?

IS THE SYSTEM NOVEL?

FIRST, the system referred to in the press reports as "double tuning" is usually more accurately described by the name of "double modulation" or "multiplex radio telephony." In radio, "modulation" means the "moulding" of the radio wave at the transmitter by voice frequen-

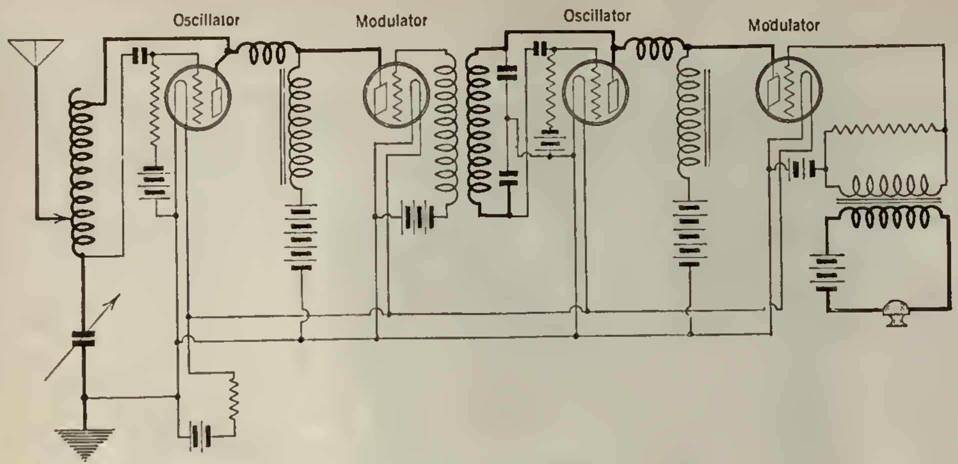


FIG. 1. A DOUBLE MODULATION SYSTEM

This diagram, which is reproduced from Morecroft's "Principles of Radio Communication," shows a circuit for transmitting by the double modulation system

cies picked up by the microphone. The device which allows the voice to be superimposed upon the radio wave is called the "modulator." The idea of double tuning or double modulation applied to a radio transmitter was shown in a patent by John Stone Stone more than 17 years ago. Just who was first to disclose a complete workable system, the writer does not know; but a sytsem similar to that described in the press reports was built by the Western Electric Company for the U.S. Navy prior to 1919. A description of this multiplex radio telephone system was given by Craft and Colpitts in the *Proceedings* of the A.I.E.E. (about 1919). For several years preceding and following this date, John Hays Hammond, Jr. was interested in double modulation systems, and his engineers developed complete multiplex radio telegraph installations which were tested by the U.S. Signal Corps and the U.S. Navy. It was while doing development work and research on these sets that the writer first became familiar with double modulation systems. In Morecroft's *Principles of Radio Communication* (pages 680–83, 1st ed.) written in 1921, complete diagrams for a double modulation system are shown. One of these diagrams is reproduced in Fig. 1. If the reader is interested in the actual connections to use in building such a transmitter or receiver, he is referred to these pages.

Just a few random references to the use of multiplex radio are given here. The engineer recently advocating its use, being a well-known pioneer in the radio field, famous for his inventions, must not have intended to claim novelty for this system. However, reporters of his address did infer that "double tuning" is new.

Before answering the next question, "Will double modulation multiply all existing radio channels?" it is necessary to describe briefly the arrangement of our present broadcasting system so as to form a background against which different systems may be viewed and compared.

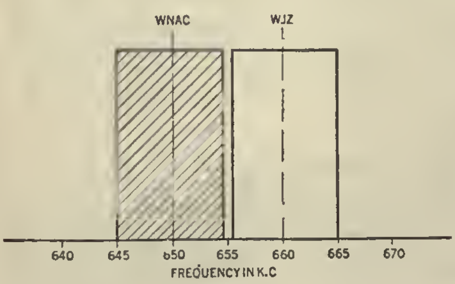


FIG. 2

WHAT IS A RADIO CHANNEL?

A RADIO channel is a band of radio frequencies, the width of which is determined by the type of transmission. Two such channels located in the broadcast "spectrum" are shown diagramatically in Fig. 2.

The word "spectrum," which is often employed in the study of light waves, has found increasing use in connection with radio waves. This is because a continuous electric wave appears in the radio spectrum as a straight line, located at a certain point in the frequency scale, exactly as a light line having a single color stands out in the light spectrum. Fig. 2 shows the location of the two radio channels assigned by the Federal Radio Commission to stations WJZ and WNAC. Each channel is designated by a number, which corresponds to the frequency (in kilocycles) or to the wavelength (in meters), of the point at which the *center* of the channel is located. Thus, looking at Fig. 2 we can say station WJZ (New York) operates on the 660-kc. channel and WNAC (Boston) on the 650-kc. channel.

Since the width of radio channel depends upon the type of transmission, a list of channel widths, in frequency, required by three well-known types of transmission is given as follows: (a) Radio telephony (broadcasting), 10 kc.; (b) Interrupted or tone-modulated c.w. telegraphy, about 2 kc.; (c) Unmodulated c.w. telegraph, less than 0.3 kc., depending upon the keying speed (words per minute). These widths remain the same whether transmission takes place in the longer or shorter wavebands, assuming precautions are taken to maintain the frequency of the radio generator constant.

The present broadcast spectrum extends from 550 kc. to 1500 kc. In order to provide for the maximum number of transmitting stations each channel is limited to 10 kc., the minimum width which will give satisfactory reproduction of music. The total number of channels available on this basis is 95. With our present serious station interference and hundreds of would-be broadcasters waiting for space in the ether, the question of the most economical use of this band is important, and it is this problem which we are considering.

THE RESULT OF MODULATION

WITH the help of Fig. 3, which shows one of the radio channels of Fig. 2 magnified, let us examine the nature of the wave disturbance caused in the ether by a radio telephone transmitting station. We will suppose that the spectrum resulting from a transmitter (such as WJZ) is shown here. When the microphone is idle, that is, no modulation taking place, the radio frequency carrier wave only is radiated. This is accurately located at the assigned frequency of 660 kc., and is represented by a single line in the spectrum. Now suppose the microphone at the station is energized by a steady musical tone of, say, 1000 cycles; the result is the formation of so-called "side-bands" shown in Fig. 3 by the shorter lines on either side of the central carrier-wave.

Digressing for a moment, if this is a picture of the frequency spectrum from a transmitter, how is it that we can hear at the receiver the musical tone impressed on the microphone? The reason we hear the 1000-cycle tone is because after the carrier-wave and either side-band has entered the receiver, they "beat" together in the detector (or de-modulator) circuit, and produce a tone of the original modulating frequency. This explanation of why the radio telephone receiver "works" is somewhat different from that usually given in popular radio articles which omit the important point of "beats" in the detector circuit and do not explain the need of the presence of the carrier-wave at the receiver.

The process of modulation at a radio transmitter is fairly complex, but it is not necessary for the reader to go into the mechanism of modulation in order to understand some of the simpler results of the process. It is necessary, however, to accept the fact that when a carrier-wave is modulated, upper and lower side-bands appear as shown in Fig. 3. Each of these is spaced from the carrier-wave by an amount equal to the frequency of the modulating tone. From this fact it is evident that, the higher the pitch of the musical note striking the microphone, the broader will be the band in the ether occupied by the transmitter at that moment. Those persons complaining that one local broadcasting station is much "broader" than another should note this point. Usually the alleged "broadness of wave" of a particular transmitter is due to the broader tuning of the listener's receiver at this frequency or to the greater power radiated by this particular transmitter.

If neither of the stations shown in Fig. 2 ever used modulation frequencies above the highest on the ordinary piano keyboard or the highest reached by the piccolo (that is, fundamental frequencies of about 4600 cycles) there would be no overlapping of one station into the channel of the other—provided, of course, both carrier waves were on their assigned frequencies. In many transmitters sudden modulation peaks may cause momentary shifting of the carrier frequency or other effects, resulting in intermittent interference being noted in neighboring radio channels.

It is understood, of course, that from the tone quality standpoint it is desirable, if permitted, to transmit modulation frequencies of higher than 5000 cycles because harmonics of various musical instruments range above this figure. And these add a great deal to the naturalness of broadcast music.

We have now defined a radio channel, shown

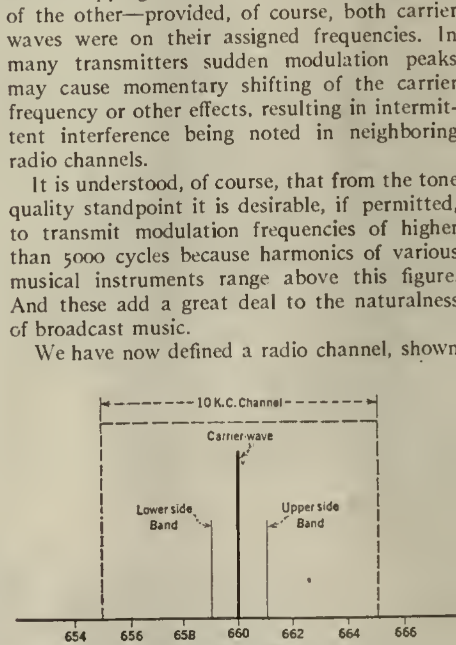


FIG. 3

that its width for broadcasting is 10 kc., and shown that the side-bands, which vary in response to the voice frequencies from 50 to 5000 cycles, occupy the full width of this channel. We are now ready to consider the more unusual system of double modulation, sometimes called "secret radio," "selective signalling," and "double tuning."

AT THE RECEIVING END

This apparatus is part of that used for the reception of single side-band signals at the Houlton, Maine, station of the American Telephone & Telegraph Co. The operator at the right is adjusting the apparatus used to pick up the signal, and the man at the left is responsible for the wire line to New York

THE DOUBLE MODULATION SYSTEM

A BRIEF outline of such a system will be mentioned so that the reader will understand how douhle modulation can be used at an experimental broadcasting station employing this system.

Instead of modulating the usual carrier wave by audio frequency currents, an intermediate frequency (i.f.), above the limit of audibility—say 20,000 cycles—is used. This intermediate frequency is, in turn, modulated by speech frequencies. The resultant is a modulated carrier wave superimposed upon another carrier which is radiated in the usual manner.

In receiving such a doubly modulated wave, it is necessary to tune to and detect the radio-frequency carrier wave, which could be, say, 660 kc.; then tune to and detect the intermediate frequency of 20 kc. and, if desired, amplify the audio-frequency signal resulting from the second detection.

A transmitter and receiver that work in the above manner are shown schematically in Fig. 4. The audio frequencies (50 to 5000 cycles) are picked up by the microphone, and are impressed on the i.f. oscillator (or generator) by means of the first modulator. The modulated output of the i.f. oscillator acts on the second modulator arranged to modulate the r. f. oscillator (or generator) so that a doubly modulated wave may be radiated from the antenna.

Only the bare fundamentals are shown at the receiver; namely, an r. f. tuner (660 kc.) and detector which feeds its inaudible output into an i.f. tuner (20 kc.) and detector. In the output of the latter are connected telephones in which the desired signal can be heard.

SEMI-SECRET TRANSMISSION

SINCE our radio receivers of to-day are intended for the reception of single-modulated signals, we do not have the second receiver unit of Fig. 4 (i.f. tuner and detector). Hence, by the use of certain combinations at the transmitter, intelligible signals from double modulated transmitters cannot be received with ordinary receivers. For this reason, engineers term such a system "semi-secret."

Some readers will doubtless ask the question, "What about the super-heterodyne—it possesses an intermediate tuner and detector." To convert a super-heterodyne into a double modulation system receiver, as in Fig. 3, it will usually be necessary, first, to alter the fixed-tune i.f. amplifier so that it can be tuned to any desired transmitted intermediate frequency (20 to 100 kc.), and, second, to eliminate the r.f. heterodyning oscillator, which is unnecessary.

An editorial in *Radio News* not so long ago stated that the rapid modulations necessary for television could be superimposed on the present carrier wave of a broadcast transmitter by means of double modulation so that *no additional channels* would be required. As we know, this same double-tuning system has been offered by others as a means for greatly increasing the broadcast channels now available in a given wave-band. The fallacy in both of the above views will be pointed out in the paragraphs to follow.

THE CHANNEL NEEDED FOR DOUBLE MODULATION

FIG. 5 illustrates the radio spectrum lines resulting from the radiation of a double-modulated radiophone transmission. In the center we have the r. f. carrier-wave located at the assigned frequency, which we will take in this example as 660 kc. Spaced equally, on either side, are the upper and lower i.f. waves separated from the carrier by the selected intermediate frequency of 20 kc. Associated with each of these are the usual upper and lower a.f. sidebands separated from the i.f. line by 1000 cycles, since, at the moment this radio spectrum was recorded, it is assumed that a steady 1000-cycle note was sounded at the microphone. If the highest fundamental musical note were played (about 5000 cycles), these side-bands would move to a position such that the two outermost bands would reach the dotted lines which indicate the limits demanded by a single channel when the double-modulation system is used. We note from Fig. 5 that this width is 50 kc. Compare this with the ordinary broadcast channel shown in Fig. 2, the width of which is only 10 kc.

Let us take this a step farther, both because it is interesting to see what happens in the ether when a single carrier-wave is multiplexed so as to carry several simultaneous conversations and also because we find that when more than one intermediate frequency is used the frequency band per conversation is less than 50 kc. wide.

Fig. 6 shows the location of the spectrum lines resulting from the simultaneous transmission of two independent audio signals, one on an intermediate frequency of 20 kc. (the lines for which

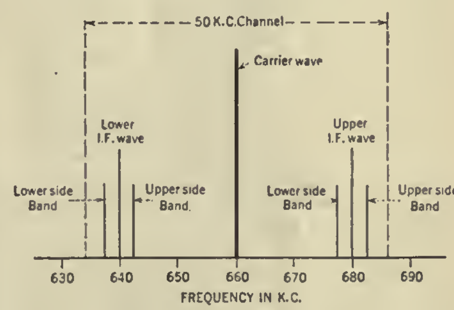


FIG. 5

are identical with those of Fig. 5), and the second on, say, 30 kc. The point to note is that the total band width here measures 70 kc., or 20 kc. more than that of Fig. 5, which is for a single conversation. To summarize, we may say the width of band required for the first multiplex channel is 50 kc. with an additional 20 kc. for each additional channel.

We conclude, therefore, that the number of broadcasters in any given wavelength band would not be multiplied if double modulation were used but actually decreased by more than one-half.

THE PRO AND CON OF DOUBLE MODULATION

LACKING the ability to glimpse into the future, we can only guide our speculations by the technical facts that we know about the infant radio developments of to-day. By weighing their advantages and disadvantages it

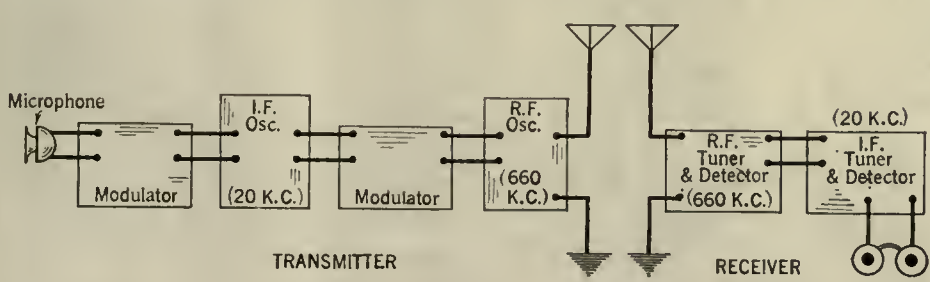


FIG. 4

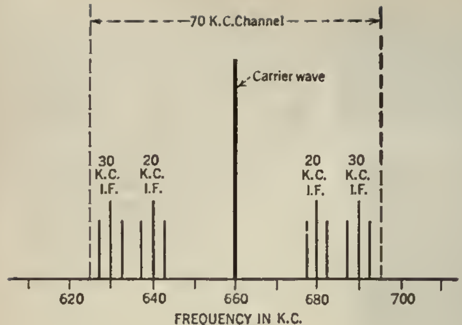


FIG. 6

should be possible to form an opinion of the likelihood of their future adoption.

The advantages of the double modulation system are:

1. Greater selectivity and freedom from static because of the double tuning feature at the receiver.

2. The advantage of semi-secrecy, if desired. Here is a system which could answer the question, "How can programs be sold to the listener?" It is very doubtful, however, if the listening public of the United States would react favorably to the proposition of paying for their radio programs.

The disadvantages of double modulation are:

1. The number of simultaneous broadcasts (or the number of conversations) would have to be greatly reduced because the width of radio channel per conversation is more than double that required for the present system of broadcasting.

2. The amount of local interference set up by a double modulation transmitter would be very serious if harmonics from the oscillators generating the carrier and intermediate waves were allowed to be radiated.

3. More costly and complicated transmitting and receiving apparatus due to extra tuning controls, tubes, and amplifiers.

Minor technical disadvantages have been omitted since these could probably be overcome by engineering development work. So far as the writer knows, there are no radio stations in our country making use of the straight double modulation system for other than experimental purposes. If this is the case, in spite of the fact that the system has been known for many years, we would infer that the disadvantages outweigh the advantages.

In concluding that our present system will not be supplanted by that of straight double modulation we see that the underlying reasons for this conclusion are based principally on the technical characteristics of this little-known radio system. It has been the object of this article to explain, as simply as possible, these characteristics.

THE SINGLE SIDE-BAND SYSTEM

MOST of the advantages incorrectly attributed to the double modulation system can be realized in the "single side-band" system. Great interest surrounds any workable system which allows the same waveband in the ether to carry, without mutual interference, twice as many conversations as it can at present. This is what single side-band transmission will do. The following paragraphs answer the questions of: What is this system? How does it work? and What will it do?"

Single side-band transmission is the transmission of modulation frequencies by the radiation of only one side-band, the other side-band and carrier wave being suppressed at the transmitter. Refer for a moment to Fig. 3 showing the spectrum lines of the ordinary transmitter. At the instant Fig. 3 was recorded we assumed that a constant musical tone of 1000 cycles (1 kc.) was impressed upon the microphone. During a musical selection the audio frequencies, as we know, may vary erratically and rapidly from 50 to 5000 cycles (or more). To represent the resulting movement of the side-bands from moment to moment, they are shown in Fig. 8 as dotted lines occupying a frequency space of 4950 cycles. Also, in this figure it is indicated that the carrier-wave and lower side-band are suppressed, leaving only the upper side-band to be radiated into the ether. The width of radio channel required for this system of broadcasting is less than 5 kc., or half of that demanded by the present system. This is an important step in the right direction.

Let us see how such a telephone signal can be received. Due to the absence of a transmitted carrier wave, messages from such a transmitter would not be understandable on our ordinary receivers. However, the carrier wave, which is steady in frequency, can be supplied locally at the receiver by an oscillating tube. Its transmission through the ether is thus made unnecessary.

In receiving signals from a single side-band transmitter, using the receiver arrangement shown in Fig. 7, the local oscillator supplying the carrier-wave (which is no longer a "carrier") would be set by the operator at exactly 660 kc. to correspond in frequency with the suppressed carrier. This must be done by ear, since if the frequency of this local beat oscillator is even very slightly off, the received signal will not have its natural quality. For instance, the voice of the best announcer could, by misadjustment, be made to resemble that of an old woman!

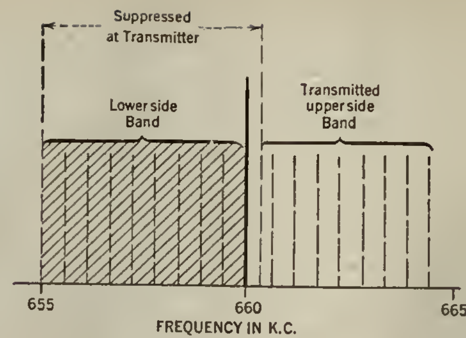


FIG. 8

To complete the answer to "How does it work?" brief mention will be made of the apparatus at the transmitter which accomplishes the suppression of the side-band and the carrier. Fig. 7 illustrates the schematic outline of one type of transmitter. The voice energy and that from the master r.f. oscillator is fed into a push-pull modulator, so connected as to suppress the carrier-wave (the frequency of which is determined by the master r.f. oscillator). Then the output of this modulator is passed through a filter and the undesired side-band is removed, leaving only one side-band (which varies in frequency from 50 to 5000 cycles as the voice frequency varies) to be amplified by the power amplifier and finally to be radiated from the antenna.

CAN IT BE PERFECTED?

THIS system affords radio telephony requiring only one-half the channel width required at present. It allows an increase in sharpness of tuning at the receiver without reducing fidelity, thus providing more selectivity. Much less power is necessary at the transmitter, since the carrier wave is not radiated. Generally there is less distortion and variation in received signal strength due to fading, because the locally generated carrier is steady. These are some of the advantages that occur with single side-band transmission. When it is coupled with double modulation still other advantages appear, one of which is the possibility of a high degree of secrecy when certain combinations are used.

The disadvantages are: Increased complication of apparatus; more skill required in the operation of the receiver; and, in our present broadcast band, the disadvantage that all our receivers would require modification. The most serious of these disadvantages is the difficulty of setting and maintaining the local oscillator at the desired frequency. Assuming transmission to take place at 1000 kc. the exactness with which the oscillator must be set is 1 part in 100,000. In the present state of technical development, this would require a highly skilled operator and precision instruments. Development work is needed to overcome the demand for such accuracy in order to make ordinary single side-band reception practical for everyone's use in the broadcast waveband.

It is the single side-band system (combined with double modulation) that has been selected for use in the American Tel. & Tel. Co.'s transatlantic radio link between the United States and Great Britain. The two photographs show parts of the apparatus used.

It seems logical to suppose that single side-band transmission will grow in use for point-to-point communication and the time will come when it will be used for the broadcasting of speech, music, and vision.

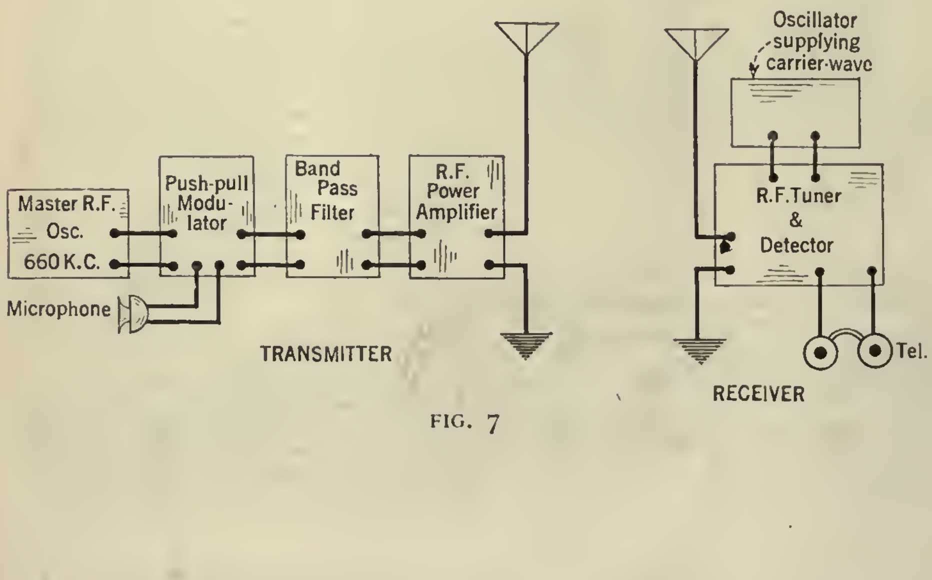
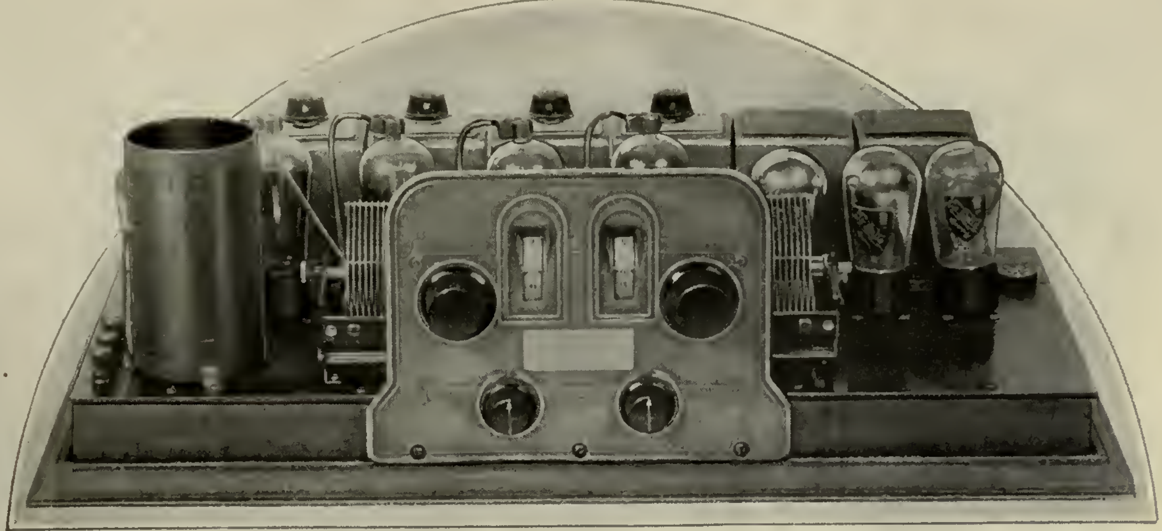


FIG. 7



SIMPLICITY IS THE KEYNOTE OF THIS SUPER-HETERODYNE

A "One-Spot" Screen-Grid Super

By W. H. HOLLISTER

FOR many years past the writer has been an ardent radio fan industriously building every new circuit which has been devised in the search for better and still better radio reception. Literally, every type of manufactured kit and every new circuit which has appeared from time to time has been built and tested, but no standard circuit ever quite came up to expectations of what radio reception should be. The author's expectations were certainly not unusual and are probably shared by the majority of radio fans, who have believed that a good radio set should give absolutely faithful reproduction of all musical frequencies, great enough amplification to bring in any station louder than local noise and play it on the loud speaker, and sufficient selectivity to cut consistently within 10 kilocycles of all normally interfering local stations. A qualifying requirement would be that the receiver satisfying these expectations must be easy to build, dependable in its performance, simple to tune, and low in initial cost and upkeep.

Early in the search for such a set, attention was attracted to the super-heterodyne system, which theoretically seemed to provide opportunity for high amplification and extreme selectivity without seriously impairing tone quality, and, at the same time, to provide a receiver simple of construction. Super-heterodynes without number were built and tried with many circuit variations tested in each receiver. One quite satisfactory set was evolved which was used by the writer in his home for several years. It employed a 50-kilocycle intermediate amplifier and with it Los Angeles and other Pacific Coast stations could be tuned-in almost any evening in the week with clocklike regularity and with volume equal to local stations. As time went on and more broadcasting stations came on the air, the repeat points upon the oscillator dial of this receiver made its selectivity less and less satisfactory, and the writer was forced to resume the search for a better receiver. At just about this time, the screen-grid tubes were made available, and birth was given to the hope of even greater amplification than was had with the old standby set using 201A tubes. Because many of the writer's friends have been so favourably impressed with the performance of the final receiver incorporating these new tubes, he has been led to prepare this article describing the processes by which it was developed, and telling how an exactly similar set may be constructed by the fan at home.

As previously stated, the goal of this receiver was to be 10-kilocycle selectivity against any local station (and within a few miles of the writer's home in Chicago there are some twenty powerful broadcasting stations operating every evening), the finest possible tone quality which could be provided consistent with 10-kc. selectivity, sufficient sensitivity to give a wide range of program choice, both local and distant; and all this to be had with absolute dependability, simplicity of control, and low initial and upkeep cost. The answer to all these requirements finally took shape in the form of an eight-tube super-heterodyne receiver having a screen-grid first detector, a conventional oscillator, three individually tuned 400-kilocycle "one-spot" intermediate amplifier stages, a second detector, and two audio stages using the new Clough system of audio amplification. The new super-heterodyne is pictured in the accompanying photographs and diagrams.

THE present article by Mr. Hollister describes the first really "one-spot" super-heterodyne which has appeared in RADIO BROADCAST. *Heretofore, the "bug" limiting the usefulness of most "supers" has been the upper and lower tuning points on the oscillator. Often, when receiving a station with the oscillator tuned to one of these points, the user would find interference from another station which would beat with the oscillator to produce perhaps a frequency similar to the intermediate frequency. The set described here is really "one-spot." It employs eight tubes, three of which are screen-grid tubes in the intermediate amplifier, which is designed to work at about 350 kc. (855 meters). Volume is satisfactorily controlled by a potentiometer which varies the voltage on the screens of the 222 type tubes. The high intermediate frequency is chosen to prevent double tuning points. The i.f. transformers are equipped with small midget condensers so that each may be adjusted by the user to the same frequency. In testing this set in the Laboratory it was found easy to do this. With all the transformers accurately tuned, the amplifier oscillates, which can be regulated by the volume control. In the Laboratory test, fidelity seemed to be improved when the i.f. transformers were slightly detuned, with, of course, a certain decrease in sensitivity. The cost of parts is about $90. Constructional details in leaflet form are available from the manufacturer of the intermediate transformers and requests should be addressed to* RADIO BROADCAST.

—THE EDITOR.

DESIGN FEATURES

AT THE outset the writer endeavored to use standard parts available on the open market for the construction of his receiver, but it soon became apparent that the requirements laid down for its performance could not be met with standard parts then available and it became necessary to enlist commercial aid in the development of special transformers for the receiver. The balance of the parts in the author's set are standard and may be easily procured upon the open market. As work upon the set progressed, it was given tests night after night and the results obtained averaged over a space of months. In final form, as pictured herewith, the eight-tube receiver operated satisfactorily in the steel frame office building where it was built and would regularly bring in stations within a thousand to fifteen hundred mile radius on the loud speaker, using a 15-foot wire strung up in the author's office, for an outside antenna could not be had. Stations such as WSN, only 10 kilocycles away from local WLS; WJZ, 10 kilocycles away from local WMAQ, only two miles away; KMOX and WDAF, 10 kilocycles away from local WEBH; WEAF 10 kilocycles away from local WCFL; and KWKH, 10 kilocycles away from WBBM,

and WHO, 10 kilocycles away from local KYW, were received consistently on the loud speaker without interference from the neighboring local channel. Such stations as WGY, WOC, and KDKA could often be heard in the daytime and frequently with only a four-foot antenna at night. The set was then taken home and tested in a wooden residence. Even better results were obtained, and instead of only a comparatively few powerful out-of-town stations being heard, little 50-watt stations all over the country came in on the loud speaker, and reception of West Coast stations became the author's early evening amusement.

The receiver shown in Fig. 3 has eight tubes placed in a straight line ranging from left to right in this order: UX-201A oscillator, UX-222 first detector, three UX-222 screen-grid intermediate amplifiers, UX-201A second detector, UX-201A first audio tube, and UX-171A power tube. Behind the tubes are the transformers; at the left is the special oscillator, L_1, and to the right the four intermediate transformers, T_1, T_2, T_3, and T_4, with their tuning knobs projecting from their tops. At the right end of the sub-base are the two audio transformers, T_5 and T_6, which are built following the specifications laid down by Mr. Kendall Clough, Director of the Research Laboratories of Chicago, in the July issue of RADIO BROADCAST.

At the left front of the chassis is the large antenna coupling coil, L_2, consisting of 80 turns of No. 16 enameled wire on a form 5" long and $2\frac{3}{4}''$ in diameter. The losses of this coil are so low that extremely sharp antenna tuning is had without the necessity of regeneration, which it is almost impossible to add to a screen-grid first detector with any benefit, as the writer's investigations have revealed. At the front center of the chassis are the two tuning condensers with their drum tuning dials, the controls of which are brought out to a small compact bronze panel which also holds a filament rheostat and on-off switch, and a potentiometer for controlling the sensitivity of the intermediate amplifier and, consequently, the volume of the receiver. The curve in Fig. 1 shows the over-all r.f. amplification of the 3-stage intermediate amplifier (4 tuned circuits). This curve indicates just why the set is as selective and sensitive as it is.

The intermediate amplifying transformers are very interesting, inasmuch as the design finally evolved ran contrary to ordinary engineering theory in that the transformers themselves actually had a step-down turn ratio! This was worked out very carefully in an effort to gain the required selectivity and is justified by the theory of the screen-grid tube used as an r.f. amplifier. The plate impedance of this tube is very high, running up into the hundreds of thousands of ohms, and it is almost an impossibility to build an r.f. transformer of the conventional type with a high enough primary impedance to obtain any great amplification. The writer therefore set out to use a tuned primary and used for this purpose a bakelite tube 2" long and $1\frac{1}{2}''$ in diameter wound with 300 turns of No. 37 enamelled wire. This primary was tuned by a 75-mmfd. midget condenser, and the circuit provided showed such a high value of impedance at resonance as to obtain a far higher voltage drop across its terminals, when connected to a screen-grid tube plate circuit, than did ordinary types of i.f. transformers. If the grid of the succeeding i.f. tube had been connected directly to the plate end of this primary, with, of course, the necessary grid condenser and leak, the selectivity of the amplifier would not have been very good, and it was here that the idea of a step-down transformer worked out so very well. A small secondary upon a $1\frac{1}{4}''$ tube, consisting of 150 turns of No. 37 enameled wire, was slipped inside the primary and connected to the grid circuit of the next r.f. amplifier tube. The result was a circuit of high amplification with sufficient selectivity so that four such transformers provided positive 10-kilocycle selectivity. By using a very large primary and a smaller secondary, tremendous amplification can be had from the tube, a little of which is then sacrificed in the transformers to gain selectivity; this is an unusual but very practical theory, judging from the results obtained.

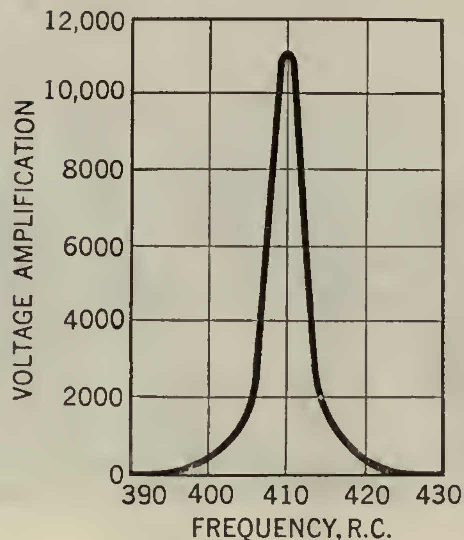


FIG. 1

"ONE-SPOT" TUNING

THE intermediate transformers are tunable by means of small knobs on top of the copper transformer shields, which may be constructed at home of 0.014" copper and which are $2\frac{1}{4}''$ wide, $3\frac{1}{2}''$ high and $2\frac{3}{4}''$ across. The transformers are placed upright inside these cans with the tuning condensers mounted on the top and insulated from the can by insulating washers. As each transformer is individually tuned after assembly of the whole receiver, no matching is necessary and the writer's set can be duplicated without any fear of poor results due to lack of proper matching equipment, which is totally unnecessary with this type of intermediate amplifier. The wavelength at which the transformers may be operated can be varied by the tuning condenser knob, and covers the range of 600 to 1000 meters, or 500 to 300 kilocycles. There are two distinct advantages to be had in using this frequency range for intermediate amplification in a super-heterodyne. The first is that the repeat points at which a station may be tuned-in on the oscillator dial are so far separated as to render the set practically "one-spot" in operation. Anyone who has ever operated a super-heterodyne will appreciate that the primary drawback of the super-heterodyne to-day is that the effectiveness of the oscillator dial is at least halved because each station is heard at two points upon the dial, instead of at only one, as in t. r. f. sets. This is due to the fact that with a 50-kilocycle intermediate amplifier, for example, the sum and difference settings of the oscillator will bring in a given station. The method of eliminating this is to raise the intermediate frequency until one set (lower) of oscillator dial heterodyne points are thrown so far away from the other set (upper) that the lower repeat points fall beyond the used tuning range. Just how this works out can be illustrated by considering the 400-kilocycle i. f. amplifier used in the author's super to cover the 200 to 550-meter band (1500 to 550 kilocycles, approximately). The oscillator settings for both extremes must be the highest and lowest signal frequency to be received plus and minus the i.f. Thus, for a 200-meter signal (1500 kilocycles) the oscillator must be tuned to 1900 or to 1100

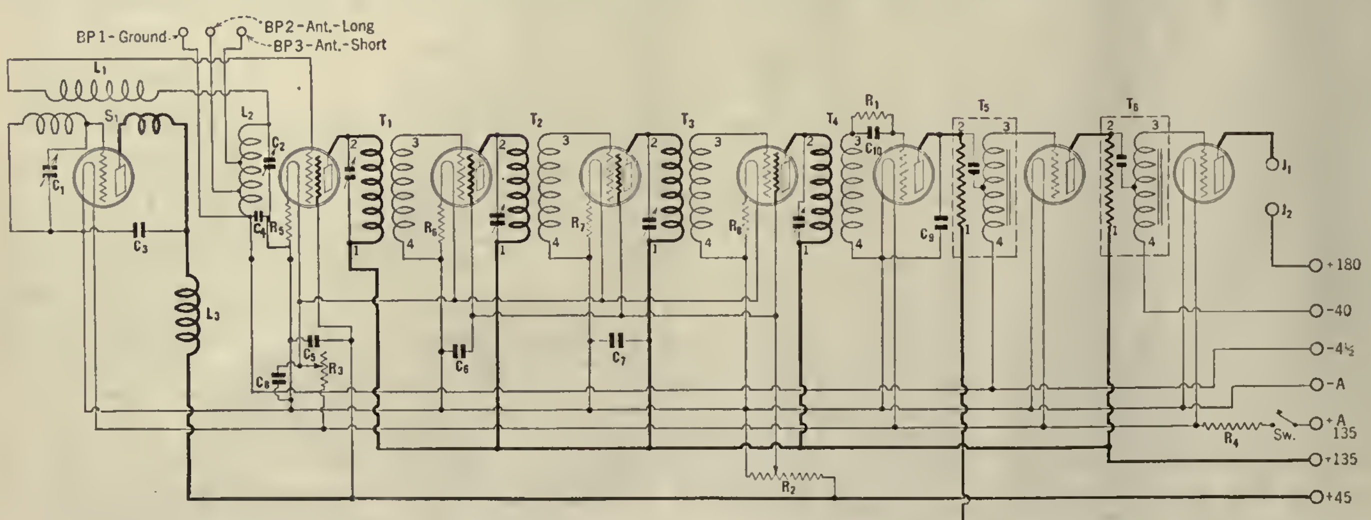


FIG. 2. THE CIRCUIT OF THE LINCOLN SUPER-HETERODYNE

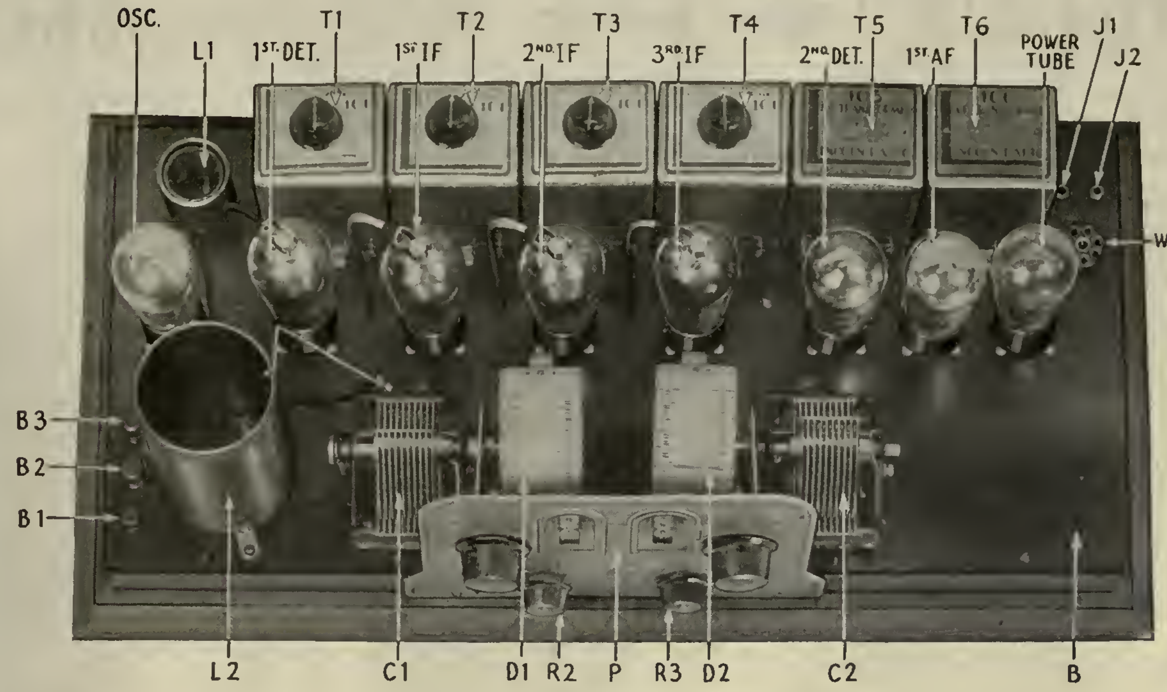


FIG. 3. HOW THE INSTRUMENTS ARE MOUNTED

kilocycles. For a 545-meter signal (550 kilocycles) obviously only the sum of the oscillator and signal frequencies can be had in a practical set, which is 950 kilocycles. Thus the oscillator tuning range must be 1900 to 950 kilocycles, or 157 to 315 meters, approximately. The 315-meter setting (950 kilocycles) will heterodyne either a 550-meter station, or a 1350-kilocycle station, which would be at 222 meters. Thus it is seen that a 400-kilocycle intermediate frequency will provide a super-heterodyne that will be truly "one-spot" for all stations above 222 meters, and that the oscillator settings for stations below 222 meters will be so far away that the input tuning circuit is only called upon to discriminate between signals at the extreme opposite ends of the broadcast wavelength band, which is not difficult with a good input circuit.

CONSTRUCTION OF THE SET

THE parts used in the writer's receiver are listed at the end of this article and, costing about $92.00 on the open market, justify the hope of having a receiver low in initial cost. The set is put together using a bakelite chassis, B, $\frac{1}{8}''$ thick and 21 $\frac{7}{16}''$ by 9 $\frac{15}{16}''$ wide, this size being chosen so that the set can be housed either in any standard table or console cabinet or in the new Silver-Marshall metal shielding cabinet which has been found to contribute much to the quiet operation of the receiver when operated near X-ray machines or other sources of local interference. At the rear of the chassis all r.f. and a.f. transformers are placed in a row, with the oscillator coil, L_1, at the left rear end of the chassis held in place by having its six connecting lugs pushed down through holes in the chassis, turned over on the under side, and all connections made to the turned over lug ends. The oscillator coil consists of a bakelite tube $1\frac{1}{2}''$ long and $1\frac{1}{2}''$ in diameter upon which are wound at the bottom a tickler consisting of 32 turns of No. 29 enamelled wire, while just above the tickler is a grid winding of 45 turns of No. 29 enamelled wire. Inside this tube is held another bakelite tube $1\frac{1}{4}''$ in diameter, upon which is wound the pick-up coil of 32 turns of No. 29 enamelled wire, the pick-up coil being connected in the first detector grid circuit. The pick-up coil is spaced equally under grid and plate coils. The tube sockets are a part of the bakelite chassis, consisting of standard socket springs riveted or screwed to the bakelite at proper points. The two variable condensers, C_1 and C_2, are fastened to the chassis in the front center and to them are in turn fastened the drum dial brackets to which is attached the control escutcheon. To this escutcheon is fastened the filament rheostat, (with on-off switch attachment), R_3, and the 3,000-ohm potentiometer R_2, which, controlling the potential on the screen grids of the intermediate amplifier tubes, also serves to adjust volume and sensitivity. The neatness and simplicity of the wiring arrangement is very easily duplicated due to the convenient location of the various soldering lugs and connection points. All battery connections terminate in the multi-plug at the right rear of the chassis. Battery connections are made to the set through a battery cable with receptacle plug. Antenna and ground connections are made through binding posts at the left end of the chassis. No panel has been shown for the receiver as it may be placed in any cabinet with wood, metal, or bakelite panel which must simply have a center slot $5\frac{3}{4}''$ wide and $5\frac{1}{2}''$ high cut so that the panel will slip behind the bronze escutcheon plate of the set. If the Silver-Marshall shielding cabinet is used, the receiver chassis is simply placed upon the wood moulding and the cabinet slipped down over the whole assembly.

The receiver requires for operation any good B-power unit capable of delivering 22, 45, 135, and 180 volts, such as the Lincoln 110 type, as well as a 6-volt A battery or good A-power unit such as the Kodel, Abox, Balkite or Sentinel types. Four UX-222 screen grid tubes, three UX-21A tubes, one UX-171A, a $4\frac{1}{2}$ and a 40-volt C battery complete the accessories, outside, of course, of a suitable loud speaker, antenna and ground. If the best possible results are desired, a slight improvement may be had by substituting a UX-112A detector tube for the UX-201A type at a slight additional cost.

In operation the receiver is simplicity itself. The rheostat need merely be turned up, the volume control knob adjusted to just below the oscillating point for the intermediate amplifier, and the two drum dials rotated at about the same dial settings to tune in station after station, near and far alike.

LIST OF PARTS

THE data for the coils used in this set is given in the text. They may be home constructed, if so desired. The rest of the parts are of standard design, and substitutions may be made. The complete parts are obtainable in kit form.

B—1 Micarta sub-base, $21\frac{3}{8}'' \times 9\frac{7}{8}'' \times \frac{1}{8}''$
BP_1, BP_2, BP_3—3 Binding posts
C_1—1 Lincoln 104L (left) 0.00035-mfd. condenser
C_2—1 Lincoln 104R (right) 0.00035-mfd. condenser
C_3, C_4, C_5, C_6, C_7, C_8—6 Potter 104 1.0-mfd. condensers
C_9—1 Aerovox 0.002-mfd. condenser
C_{10}—1 Aerovox 0.00015-mfd. condenser with clips
D_1—1 Silver-Marshall 806L (left) drum dial
D_2—1 Silver-Marshall 806R (right) drum dial
J_1, J_2,—2 Yaxley 420 tip-jacks
L_1—1 Lincoln 102 oscillator coupler
L_2—1 Lincoln 103 antenna coupler
L_3—1 Silver-Marshall 275 r.f. choke
P—1 Lincoln escutcheon control panel
R_1—1 Aerovox 2-megohm grid leak
R_2—1 Yaxley 3000-ohm potentiometer, No. 53000
R_3—1 Yaxley 10-ohm midget rheostat
R_4—1 Carter 0.57-ohm resistor, type H$\frac{1}{2}$
R_5, R_6, R_7, R_8—4 Carter 10-ohm resistors, type RU10
SW—1 Yaxley switch attachment, No. 500
T_1, T_2, T_3, T_4—4 Lincoln 101 tuned i.f. transformers
T_5—1 Lincoln 105 1st. a.f. transformer
T_6—1 Lincoln 106 2nd. a.f. transformer
W—1 Jones 8-lead battery plug and cable (special)
Tube socket assemblies
Wood sub-base supports, $21\frac{3}{8}'' \times 1\frac{3}{8}'' \times \frac{5}{8}''$
Small parts assortment consisting of screws, nuts, lugs, bus-bar, spaghetti, flexible wire, Belden flexible shielding braid and screen-grid clips

The 222 Tube as an R. F. Amplifier

By GLENN H. BROWNING

THE author's purpose in this short article is simply to give the readers of this magazine some data and measurements which have been made using the screen-grid tube. Perhaps some of us have thought of using this tube in an impedance or resistance coupled amplifier, and to those the data given here will be especially interesting.

—THE EDITOR

AS THE readers of RADIO BROADCAST know, the screen-grid tube is designed primarily as a radio-frequency amplifier. The second grid screens the control grid from the plate, as its name indicates, so that the effective capacity between the two is very small. Consequently, the tendency to oscillate in a multiple stage tuned radio-frequency amplifier, due to the capacity between grid and plate in the amplifier tube, is considerably reduced.

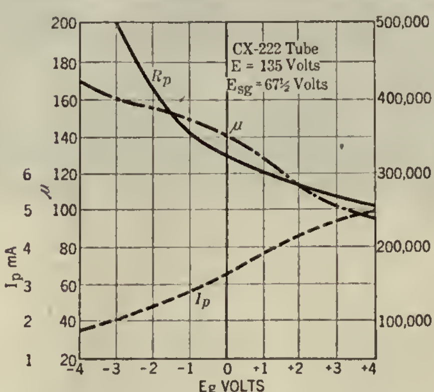
Another characteristic of screen-grid tubes is the high amplification factor. Coupled with this is a high plate resistance, so that the ordinary tuned radio-frequency transformer is not suitable if even fair efficiency is to be obtained.

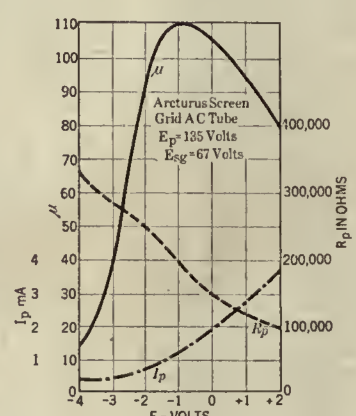
The writer has been able to obtain three distinct types of these tubes. The first type is the R.C.A. or Cunningham 222 tube. This is a d.c. operated tube requiring 3.3 volts across its filament. The essential dynamic characteristics are shown in Fig. 1. These curves were taken with 135 volts on the plate and $67\frac{1}{2}$ volts on the screen grid. The amplification varies, as will be noted, from 170 to 99, being about 152 with a grid bias of minus $1\frac{1}{2}$ volts. With this same grid bias, the plate resistance is 385,000 ohms and the mutual conductance 0.000395 mhos.

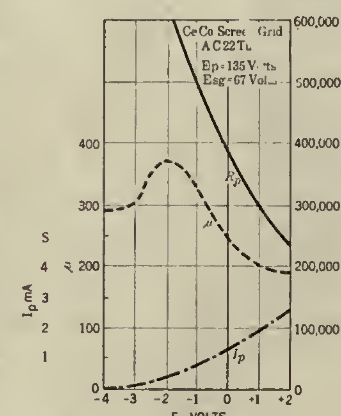
Fig 2 shows the dynamic characteristics of the Arcturus screen-grid tube. This is an a.c. 15-volt tube of the heater type. At the same operating point, i.e., 135 volts on the plate, $67\frac{1}{2}$ volts on the screen grid and $1\frac{1}{2}$ volts negative bias, the amplification factor is 106, the plate resistance 220,000 ohms, and the mutual conductance 0.000482 mhos.

Fig. 3 gives the same characteristics for a CeCo a.c. 22 tube. The heater operates at 2.25 volts a.c. as in the 227. With $1\frac{1}{2}$ volts negative grid bias, the amplification factor in this case is 362, the plate resistance 560,000 ohms, and the mutual conductance 0.000646 mhos.

It will be noted that both types of a.c. screen grid tubes have a higher mutual conductance than the d.c. tube and consequently are better from the theoretical standpoint of designing a suitable t.r.f. transformer for their use.





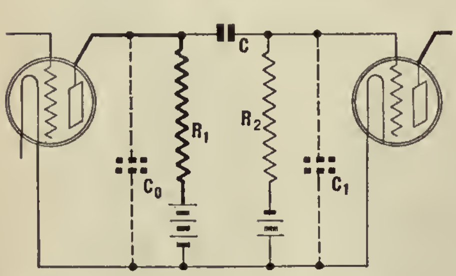


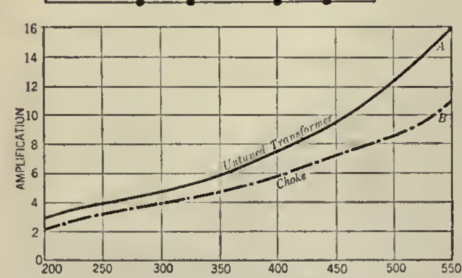
ABOVE—FIG. 1. LEFT—FIG. 2. RIGHT—FIG. 3

There are two general methods, aside from regeneration and the super-heterodyne principle, of obtaining radio frequency amplification. One is by an untuned amplifier such as is shown in Fig. 4, where a resistance, choke, or a fixed transformer is used as a coupling device. The second is a method of tuning the amplifier to the incoming signal by means of a tuned radio-frequency transformer coupled either directly or through a primary winding as shown in Fig. 6.

A mathematical analysis plus a few measurements on the capacities between the elements of the screen-grid tube will show that only a small amount of amplification may be expected at radio frequencies with either resistance or impedance coupling. The capacity, C_1, between the control grid and the filament of the screen-grid tube is about 10 mmfd., and the capacity, C_0, between plate and filament about 40 mmfd. under usual operating conditions. The first capacity, as far as alternating current is concerned, is across R_2 in Fig. 4, while the second is across R_1. Thus the maximum impedance obtainable in the coupling device is $\frac{1}{C\omega}$ where $C = 50$ mmfd. and $\omega = 2\pi \times$ frequency. At 200 meters $\frac{1}{C\omega} = 21{,}200$ ohms., and the maximum amplification of the system using a tube with a plate resistance of 560,000 (CeCo a.c. 22) ohms, and an amplification factor of 362, would be $\dfrac{\mu\frac{1}{C\omega}}{R_p + \frac{1}{C\omega}} = 13.2$. The amplification may also be simply calculated by multiplying the load impedance by the mutual conductance. 21,000 times 0.000646 gives 13.6 as the amplification, agreeing quite well with the former figure. This value of amplification can never be fully obtained, as the resistance or choke used as coupling is in parallel with these capacities and reduces the effective impedance slightly below 21,000 ohms. Fig. 5, curve A, shows the amplification obtained at different frequencies with one stage of choke coupled amplification using r.f. choke coils and a 0.006-mfd. coupling condenser. It is very apparent that tube capacities play an important factor, for at the long wavelengths or low frequencies a very fair amount of gain is observed while at the high frequencies almost no amplification is obtained. Fig. 6, curve B, shows the amplification measured with an untuned radio-frequency transformer.

Thus, analysis and measurements make us discard untuned amplifying systems at radio frequencies so that the solution of obtaining the highest gain possible with a high-mu tube must lie in tuning the amplifier to the signal.





ABOVE—FIG. 4. BELOW—FIG. 5

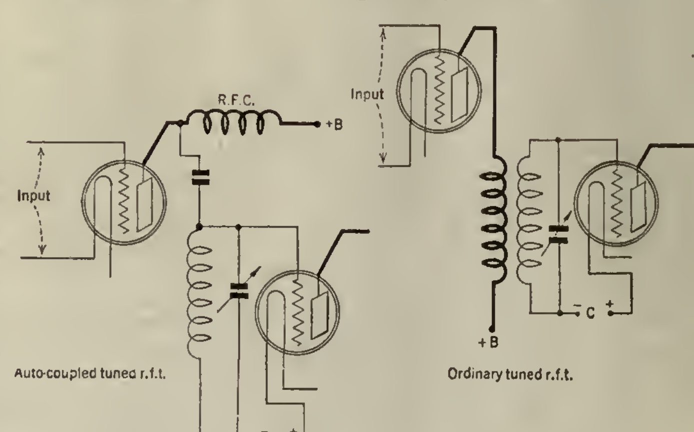


FIG. 6

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

The Laboratories Grapple with Aircraft Radio

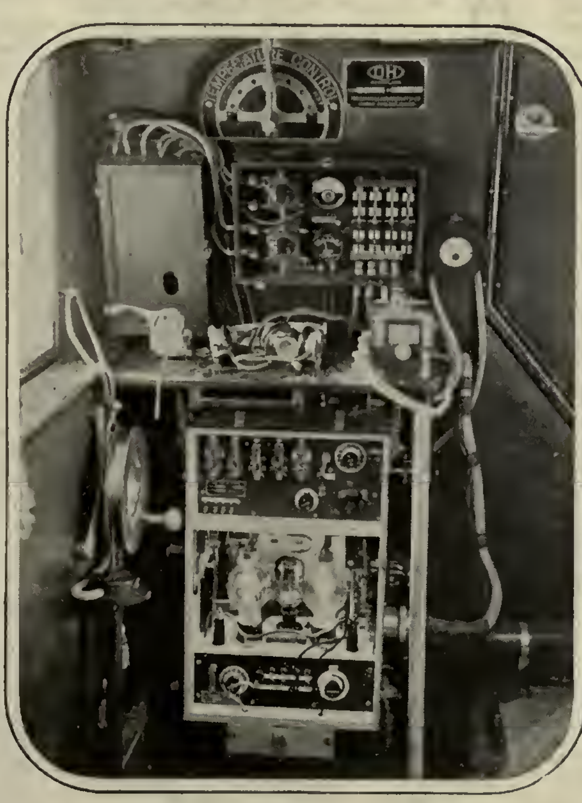
AIRCRAFT radio, during the last few weeks, has performed with such spectacular effectiveness that any aviator who now attempts a long distance flight without its aid is flaunting providence. Since the July *March of Radio* editorial, scoring aviation for neglecting radio, was written, the world has been able to trace, through frequent radio bulletins, the progress of several amazing long distance flights. Three aviators flew from San Francisco to Brisbane in three tremendous jumps, with the whole world rooting for their success as they fought through wind and storm. The first transatlantic flight with a woman passenger was similarly applauded. Nobile and his companions were found in the Arctic drift only through the effectiveness of radio directions. Radio has covered itself with glory as the faithful companion of the aeronaut, guiding him through storm to distant airport, reporting his progress to the world and, finally, performing incredible missions of rescue.

Spectacular feats are the vehicle by which the world is informed of the progress of science. The real advances are made in scientific laboratories where a few geniuses, aided by a staff of assistants, grapple with the problems which carefully tabulated study of known performance reveals as the need of the times. The world is startled into consciousness by its Lindberghs and Nobiles because technicians are not salesmen. Recent technical literature records victories of the laboratory as significant and important as the performances which make headline material for the press.

Two papers were presented before the New York section of the Institute of Radio Engineers on June 6, which set forth the present development of aircraft radio equipment in a comprehensive and authoritative manner. One of these, "Development of Radio Aids to Navigation," by Dr. J. H. Dellinger and Haraden Pratt, traces the history of aircraft beacons from their war service to the present. The interlocking type of directive beacon, which automatically gives visual indication to the pilot as he flies along any well equipped airway, is the culmination of years of practical development work by the Bureau of Standards. No bearings need be taken either by goniometric stations on the ground or by the aviator in flight, a dial in the plane's instrument board serving to show whether the plane is on its course or to the right or left of its course. Dr. Dellinger's beacon system will save more lives in the next ten years than the parachute.

Assisting Dr. Dellinger was F. W. Dunmore, who contributed basic ideas to the modulation type of beacon and did much of the laboratory work. Harry Diamond is credited with valuable contributions in the design and construction of airplane receiving sets and research incident to the practical operation of the beacon and its modulating arrangements. Dr. E. Z. Stowell is mentioned by Dr. Dellinger for his work with earlier circuit arrangements and studies of field intensity diagrams.

The second paper, delivered at the same meeting of the Institute, is entitled "Aircraft Radio Installations," by Malcolm P. Hanson of the Naval Research Laboratory at Anacostia. It describes the various transmitters installed aboard the dirigible *Shenandoah*, including the 2-kw. i. c. w. transmitter which gave good night reception on one occasion for a distance of 5000 miles. Mr. Hanson also describes the 150-watt transmitter aboard Byrd's plane, the *America*, those aboard the *Old Glory*, the *American Legion*, Wilkins' short-wave set and several transmitters developed by the Navy and the Burgess Laboratories. This comprehensive review indicates that aircraft radio equipment is in a high state of development and it is to be hoped that the radio industry follows up the advantage which it has gained by the recent practical demonstrations of radio's service to long distance flights. A nationwide net of radio communication to support commercial aviation is radio's newest mission which should be pursued with the utmost vigor. Only with such coöperation will radio demonstrate its true value as an adjunct to air navigation.



A MODERN AIRCRAFT INSTALLATION

This radio telephone and telegraph transmitter and receiver is installed on a British commercial air liner. The transmitter is rated at 150 watts. The instrument box below the table contains at the top the receiving unit. Below it are the transmitting tubes, and at the bottom the tuning controls for the transmitter. The reel at the left unwinds the trailing antenna

Guggenheim Fund Shows the Way to 'Frisco

THE Daniel Guggenheim Fund for the Promotion of Aeronautics has announced that it will install, along the Los Angeles-San Francisco airway, a complete aeronautic weather reporting service. Coöperating with the fund are the Aero Service of the Weather Bureau and the Pacific Telephone & Telegraph Company. Two terminal stations are to be erected at the ends of the route, supported by twenty-two observation stations. The total time for the collection of reports at both terminals and the exchange of complete data between them will be less than twenty minutes. The reports are to be made three times daily and are to be communicated by telephone and radio to trained meteorologists who will forecast flight conditions and advise departing pilots which of five alternate routes should be followed.

At the NEMA Convention

DURING its session in Chicago, the Radio Division of the National Electrical Manufacturers' Association adopted a number of resolutions which were based on sound commonsense, making a pleasing contrast to the stand taken by some of the radio industry's representatives last April, before the Federal Radio Commission, in practically opposing the Engineers' Plan of Allocations.

The Association recommended that "greater consideration be given to those stations which broadcast programs satisfying a wide variety of interests or groups," and it condemned those which "now act purely as house organs in selling merchandise for one firm or which exclusively broadcast programs devoted to furthering the interests of some particular group, creed or class."

This is a direct fling at stations acting as advertising mediums for one advertiser and those owned by a single political party, church or sectarian group. The Association directly approved the Engineer's Plan of radio broadcasting channel allocation.

DURING the convention, NEMA announced the publication of *The Radio Market*, which is a valuable analysis of how radio is distributed, the stocks of all classes of radio goods in the hands of dealers, classified both by geographical distribution and by cities of different sizes.

A study of the analysis shows that there are too many radio outlets in cities of a million and larger and that the dealers in cities of from 500,000 to a million appear to be in the most favorable position with regard to size of stocks and turnover. The dealers in the smaller communities usually combine associated lines in a manner which counterbalances their smaller radio turnover. The number

of active radio retailing outlets seems to have been stabilized at a figure of 30,000.

It was also announced that the NEMA handbook of radio trade-in values would be distributed in a few months with a view to standardizing the allowances made for used radio receivers in the purchase of new ones. This step is necessary for tapping the re-sale market, which the industry has been able so far to neglect almost completely. So long as radio does not repeat the well nigh disastrous course of the automobile business, in over-valuing the second-hand product, the establishment of a regular second-hand market will open a new re-sale field comprising prospects who are already the owners of obsolete radio receivers and have minimum selling resistance. The automobile industry met the second-hand problem by over-valuing new cars sufficiently to make trade-in values as attractive as possible to the used car owners.

R. H. LANGLEY of the Crosley Radio Corporation presented a chart before the NEMA convention which illustrated the ridiculousness of the so-called Equalization Amendment, to which we referred in the July *March of Radio* under the caption, "The Inequalities of Equalization."

The Langley chart is reproduced below. The bottom cylinders in the diagram show the area and population of the five zones created by the Radio Act of 1927. The diameters of the cylinders are proportionate to the areas of the zones and the heights to the populations. The first four zones have an almost equal population, but the fifth zone is far below par. The areas of the zones differ greatly, the area of the fifth being approximately thirteen times that of the first. The upper cylinders show the number and total power of the broadcasting stations assigned each zone, the diameters being proportionate to the former and the heights to the latter. The Davis Amendment requires that the power assigned to the zones be equal; in other words, that the heights of the upper row of cylinders be the same, regardless of the proportions of the lower row of cylinders—that is, the areas or populations of these zones. Such is the task that the Federal Radio Commission now has on hand.

Keep Commercialism Out of the Amateur Bands

PAUL M. SEGAL, general counsel of the American Radio Relay League, has prepared a scholarly opinion as to the type of messages and the character of stations permissible in the amateur band. After carefully tracing the foundation for his opinion, he concludes that "an amateur operator, at an amateur radio station, may, under the law, accept for transmission, transit, relay or delivery a message of any kind of text, import or source, so long as no money or other valuable consideration is directly or indirectly paid or promised to him, or charged or accepted by him, subject, of course, to the general laws against obscene or profane language over the air."

Any experimental work, conducted for the benefit of manufacturers and not as the personal hobby of the amateur conducting it, is not therefore permissible in any of the amateur bands. In view of the great curtailment of frequency space recently experienced, the amateur is justified in resenting any invasion of these rights and, for his own protection, should jealously guard against any professional use of the limited space in the air assigned him. Such services as those performed by 6ARD for the San Francisco *Examiner* in reporting the flight of the *Southern Cross* are legal in the amateur band only if no emolument, direct or indirect, was paid to the amateur station, according to Segal's definition of an amateur station.

Harrisburg, Ill., Needs a 500-watt Station

A VAST preponderance of the letters we receive in comment in our policy of urging persistently the reduction of the number of stations express hearty approval on the part of our reader body. As a matter of fact, although we have frequently named names and condemned broadcasting congestion in no uncertain terms, only one listener not professionally connected with a broadcasting station has ever protested our fight for better broadcasting conditions. Therefore, the receipt of a letter from Joseph R. Tate, operator of Station WEBQ of Harrisburg, Ill., accusing the writer of prejudice against the small station and of not knowing what he is talking about, has, at least, an element of novelty.

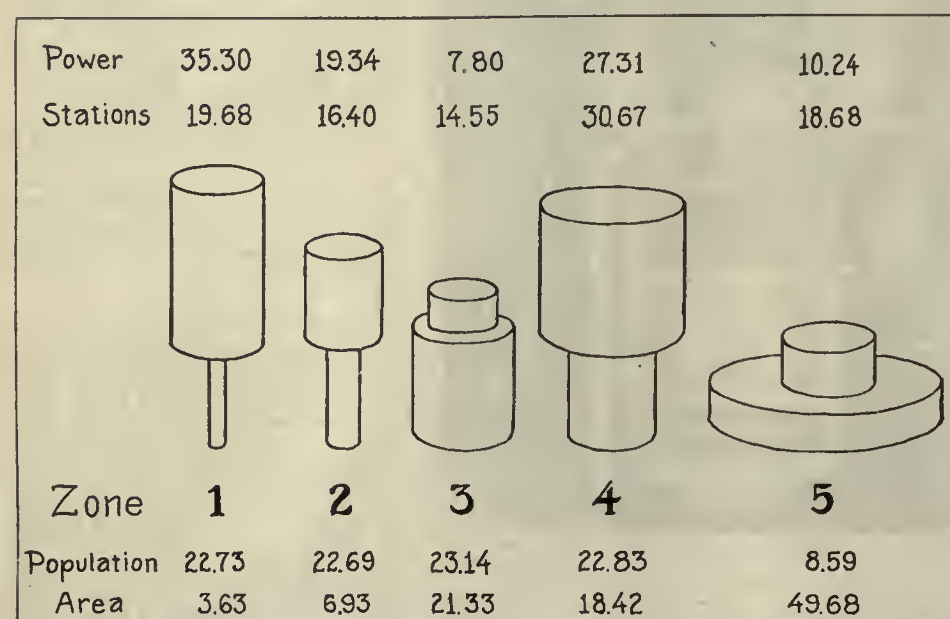
Mr. Tate's plea is based on a thorough survey of radio set owners in southern Illinois, covering every town and hamlet south of Springfield, Ill., and some in Kentucky and Missouri. This survey was made in the form of a petition to the Federal Radio Commission for an increase of power. According to Mr. Tate, who was much gratified at having secured the use of the names of 2800 set owners, this is only one-tenth of the owners in that territory. Even assuming that the 28,000 owners unanimously approved Mr. Tate's appeal —and this is not as impossible as it seems because most people will sign any kind of a petition—I am certain that WEBQ does not desire favored treatment, but merely an accommodation proportionate to what its service area deserves.

According to the latest estimates, radio sets are now available to 27,850,000 people in the United States. If one radio transmitter is deserved by every 28,000 radio listeners, the total number needed to give equal distribution would be about 1,000 stations. With the limited frequency space available, the operation of that number of stations would result in such hopeless confusion that, instead of radio giving service to nearly 28,000,000 people, it would simply deprive these people of the use of radio receivers. A lesser number of stations, properly distributed geographically, however, would assure good reception, not only to Harrisburg's 28,000, but to the entire listening audiences.

While we have not hesitated to make light of the service rendered by most of the smaller stations, our plea for the elimination of stations is based principally on the fact that the first step to good radio service is the elimination of congestion. We have no prejudice against the small station, if it could exist without curtailing service to the listener. Technical progress in the next few years will undoubtedly serve to increase the number of stations which can operate happily in the broadcast band, and then Harrisburg can maintain its pride of the air without depriving some other equally deserving locality of good radio service. But, faced with present conditions, we can only continue to urge an immediate reduction in the number of stations to the actual capacity of the band.

Many pleas are presented by various communities and organizations that they are of sufficient size and importance to be deserving of a broadcasting station of their own. The Socialists of New York City, for example, who in 1925–1926 had an enrollment of 11,943, feel they deserve a broadcasting station of their own and are raising a mighty howl of protest because WEVD was among the stations listed for the scrap heap by the Federal Radio Commission. Other bodies represented on the air in New York are the International Bible Students, the Paulist Fathers, the Italian Educational Association, the Seventh Day Adventists and various other special interests. If a station representative of Italians deserves a place of its own on the air, then rights also should be accorded to the forty or fifty other substantial nationalistic groups in New York. The same principle applies to a score or more of sectarian interests. Political bodies and fraternal organizations deserve like rights. A broadcasting structure based on such qualifications would obviously be a hopeless mess of confusion lacking public support. If Harrisburg, Ill., deserves a station for its 28,000 listeners, so does every other group of 28,000 listeners.

Those who view broadcasting as an inherent



HOW BROADCASTING POWER IS DISTRIBUTED TO-DAY

The heights of the five lower cylinders are proportional to the population of the five radio districts in the United States, and their widths to the areas of these districts. The upper row of cylinders indicate by their heights the relative broadcasting power in these districts, and by their widths the number of stations

right, accruing to special groups, whether based on population, geographical area, religious creed, political association, fraternal membership or foreign extraction, overlook the fact that the only sound basis for a broadcasting structure is the greatest service to the greatest number. The most effective distribution is based upon stations which do not represent any special interest, commercial, political or sectional, which give equal opportunity to all types of program material having public favor and which are of sufficient size and power to serve an area and radio population worthy of the channel space which they occupy.

The Empty Pool

THE Radio Manufacturers' Association announced that a reduction in the cost of radio sets is in prospect because its plan of patent pooling was ratified by its Convention in Chicago with only one dissenting vote. The plan provides for a free exchange of patents without license fee. That is, we note, free exchange of what are called "Class B" patents, "not displaying invention of high order." Class A patents, considered basic, are not a part of the plan. Its approval by the Convention means that the plan will now be submitted to the members, of whom a majority must approve to make it official. Even then, such favorable action does not bind individual members to contribute their patents to the free pool. Apparently, those who have no patents will contribute them to the pool for the benefit of those who do possess patents. The latter, however, will not be required to pool their patents. It was a good publicity story, anyway.

Engineers in Quantity Production of Standards

THE preliminary draft of the report of the Committee on Standardization for the Institute of Radio Engineers has been circulated for comment and indicates an amazing amount of work performed by an extensive committee of experts. The first and major part of the report consists of several hundred carefully worked out technical definitions, applying to every phase of radio communication. A few pages are devoted to standard graphic symbols for the principal radio circuit elements, which we hope will be put into general use by all publications. The remainder of the report is concerned principally with standard methods of measuring the characteristics of vacuum tubes and the performance of radio receiving sets and electro-acoustic devices.

It is obvious that the Institute's committee and every one of those who have contributed their time and services to its problems are deserving of whole-hearted praise for this comprehensive piece of work.

Long Waves Needed in Transoceanic Service

SO MUCH attention has been given to the possibilities of short-wave channels in international communication that it is interesting to recite the expert opinion of O. B. Blackwell, transmission development engineer of the American Telephone & Telegraph Company, who has been identified in technical phases of transatlantic telephony since the first experiments conducted several years ago. Three short-wave channels, approximately 16, 22, and 35 meters, have been found to complement each other providing a good signal level during the hours that the 5000-meter long-wave communication channel is at its minimum effectiveness.

A COIL TEST AT THE BUREAU OF STANDARDS

The Radio Section of the United States Bureau of Standards is doing valuable work in determining standards of accuracy and efficiency in all kinds of radio apparatus. H. B. DeGroot is shown testing a coil to determine the best shape for coil forms.

After relating in some detail experience with various frequencies and expressing the hope that the "reliability of short-wave channels can be made such as to some day eliminate altogether the necessity of the long-wave channel with its much more extensive plants. . . ." Mr. Blackwell continues: "So far, data available regarding short waves do not suggest that they ever will give a reliability of service comparable to that for similar distances over land wire circuits. It is our present expectation, therefore, that the giving of suitable service between America and Europe will require the continuation of the long waves, even though such waves demand a much more extensive and complicated plant than do the short waves."

Although short-wave transmitters perform with amazing efficiency under ideal conditions, the total percentage of time which any high-frequency channel serves between any two given points is distinctly limited.

Here and There

SO LONG as broadcasting service is limited to tonal reception, its predominant function is musical entertainment. But even without means of transmitting graphic information through the eye, which is essential to the efficient distribution of specific facts and data, radio is already a valuable disseminator of education. According to L. R. Alderman of the Bureau of Education of the Department of Interior, more than 65 universities and colleges, enrolling over 5,000 students, have been using broadcasting for regular courses. Morse Salisbury, Chief of the Radio Service of the Department of Agriculture, says that 107 stations are broadcasting his market news service and 181 the weather reports. Ten thousand letters a month are the audience's response to these valuable services and, in the last year, 200,000 copies of a radio cook book have been distributed. The time is not far distant when Weather Bureau maps will be broadcast as a part of the weather forecasting service.

A DECISION of interest to broadcast managements was rendered by Judge Valente in an opinion denying injunction to George Frame Brown against WOR. It appears that George Frame Brown, while an employee of the station, appeared as a leading character in "Main Street Sketches." These sketches have been presented as a regular weekly feature with the same cast appearing in a new sketch each week. Mr. Brown, on leaving the cast, sought to prevent the continuance of the sketches with a new leading character. The court held that mimicry of the principal character "is no more the subject of exclusive appropriation than the method of portrayal of a new rôle in an opera by an artist who 'created it', in the sense of being the first to portray it." The obvious wisdom of this decision is generally agreed upon by all, with the possible exception of Mr. Brown.

THE cost of broadcasting the Republican National Convention through 42 stations amounted to $77,000., or a little over a dollar a minute, since the total time involved was 72,000 minutes. Forty-five thousand miles of telephone circuits were involved, which cost $1,650 an hour for 20 hours, or $33,000; rental of a special trans-continental circuit was $1,200 an hour, or $24,000; pick-up and input installation at Kansas City, $10,000; salary of technical and reporting personnel, $10,000.

ALTHOUGH of rather limited circulation, a telegraphic questionnaire by WBBM of Chicago confirms the expression of RADIO BROADCAST readers that only eight or nine stations are wanted in Chicago, with the following receiving the predominant number of favor-

able expressions; KYW, WGN–WLIB, WMAQ–WQJ, WLS, WBBM–WJBT, WENR, WEBH–WJJD and WCFL.

STATIONS WHAS and WLAC, both in the southern district, are installing 5,000-watt transmitters.

THE Van Sweringen interests and the Cleveland Electrical Illuminating Company are taking over the operation of WTAM-WEAR, according to a local news item.

STATIONS WEBJ and WLBM, in the first district, have done the most graceful courtesy to the radio audience by voluntarily surrendering their licenses. Hundreds of less considerate and less experienced organizations are quite ready to take their places as broadcasters.

THE Independent Broadcasters' Association has been formed in Chicago with the executives of stations WCRW, WPEP, WCBS, WHBL and WKBB represented among its officers. In its initial statement, the Association says "the right of communities to have local broadcasting stations, as they have local newspapers, is at stake. No one would suggest that 50 smaller newspapers should be destroyed to make room for a single national magazine."

If the nation's available supply of printing presses were limited to 89, there is no question that the limited facilities would be doled out among the greatest and best possible newspapers. It begins to look like intentional stupidity when self-styled defenders of special groups proclaim their alleged right to frequency space which should serve millions. Broadcasting is wholly unsuited to take the place of a local meeting hall or a local newspaper. It is a national and regional medium and the sooner it ceases to be chamber of commerce ballyhoo, the sooner radio will grow to its true force.

A TEN per cent reduction in the rate applying to radiograms between the United States and Australia is the result of linking Rocky Point with the short-wave beam service between Montreal and Melbourne.

THE Dollar Lines are erecting twenty 1-kw. shore stations in New York, San Francisco, Manila, Honolulu and Shanghai, at a total cost of a million dollars, utilizing the new channels assigned them in the 20-meter band. They announce a combination radio and mail service to China at low rates, consisting of radio direct to ships en route to China and thence by mail on arrival at Shanghai.

REPRESENTATIVES of the Canadian Government are making another plea for additional inroads into our overburdened frequency allocations in order to extend still further their broadcasting services. Canada now has six exclusive channels and twelve shared channels, as compared with 77 exclusive channels and twelve shared channels for the United States. It has only 5.5 stations per channel as compared with 7.7 in the United States. Our frequency space is approximately five times as extensive as that assigned to Canada, but our population is twelve times as large and the number of radio sets twenty-five times as large. The total power of our broadcasting stations per channel is somewhat over three times that of the Canadian channels.

When the Canadian commissioners visited the United States, shortly after the appointment of the Federal Radio Commission a year and a half ago, we urged that they be given a just share of the broadcast band, particularly in view of the miserable pirating by American stations then current. They were dealt with generously and are not loading their channels nearly as heavily as we are. Hence their present plea is made without full appreciation of the justice of the situation.

A PICTURE WIRING DIAGRAM FOR THE BLIND

The large sheet of paper which the blind man holds is a receiver constructional data sheet printed in the Braille system for the blind, with a wiring diagram in relief dots. It was printed by the American Braille Press, in coöperation with French radio corporations, which furnished the skeleton framework in the blind man's left hand. The framework is furnished with tuning dials marked with raised characters.

THE Chairman of the Federal Radio Commission, Judge Robinson, during a visit of inspection in New York early in June with Commissioner Caldwell, issued a forceful statement to the effect that "on all hands it is conceded that, for the general public interest, there must be fewer stations. . . . The fulfillment of the law implies more than mere local interests, likes and dislikes. In major consideration, the problem is a national one. For the good of the whole country, not so many stations as formerly will be licensed in certain sections of the Union. The Federal Radio Commission knows exactly what it is doing and that it is acting within its definite powers."

Rumors reach us that this decisive opinion, expressed by the newest Commissioner, will be crystalized in a definite plan of allocation to be put in effect on September 1. Judge Robinson is to be congratulated upon the speed with which he has grasped the crux of the radio problem and for his definiteness in stating, in no uncertain terms, what course the Commission proposes to follow. The first public statements of most of the Commissioners have been farcical statements of optimism to the effect that radio is not as bad as it sounds.

A NEW 35,000-watt broadcasting station, operating on 1525 meters, has been placed in operation at Lahtis, Finland.

COMMANDER HOOPER, in a memorandum to the Federal Radio Commission on short-wave allocations, stated that the increase in foreign short-wave stations since March 20 has been fifty per cent as compared with two per cent in the United States. It must be realized, however, that the numerous American services established before that date serve to give us a predominant position in the short-wave field.

THE opening of direct radio telephone communication between Holland and the Dutch East Indies was staged at the International Press Exhibit at Cologne on May 28. The dispatch was so garbled that the exact locations of the stations in Holland and Java involved cannot be given.

RADIO was honored by a place in the Republican platform, drafted at Kansas City, with an innocuous platitude to the effect that the Republican party is in favor of radio broadcasting. The election of Candidate Hoover, however, would be a great blessing to radio because he understands its problems thoroughly by intimate contact therewith and has had actual experience with broadcasting problems. Governor Smith, the Democratic nominee, also appreciates the value of radio as a medium of political expression, although we would not like to see his private method of pronouncing the word "radio" become the generally accepted usage.

THE United States Customs Court sustained the protest filed by H. Scott Martin that the duty assessed on radio tubes should be 30 per cent. instead of 40 per cent. because they should be classified as "machines and parts thereof not specifically provided for" rather than "manufactures of metal, not specifically provided for" as they have been classified by customs collectors in the past.

THE Zenith Radio Corporation, in its annual report, covering the operations of the last ten months, reports net earnings of $727,995.29, after deducting depreciation, commissions, bonuses, royalties and taxes. Inventory amounts to about a quarter of a million.

THOMAS A EDISON will build combination · electric phonographs and radio receivers in coöperation with Splitdorf. Presumably these sets will be for listening to sporting events which, according to Mr. Edison's statement some months ago, is the only useful service so unmusical a device as radio can render.

J. D. R. FREED was recently issued patent No. 1,671,959, describing the use of bypass condensers as a means of eliminating reactive coupling in radio circuits. If this patent is sustained in the courts, practically every receiving set manufactured will fall within the scope of its claims. It looks like a great opportunity for a lot of lawyers to make a lot of money. . . . Judge J. Brewster of the U. S. District Court in Massachusetts held, in a decision favorable to the Hiler Audio Company and unfavorable to the General Radio Company, based on patent 1,589,692, that the patent is basic for all forms of double-impedance audio frequency when plate and grid impedance are located within one can or housing. The decision ought to please the can manufacturers. . . . A recent list of licensees under John V. L. Hogan's patent No. 1,014,002 reveals that over 90 per cent. of the radio sets manufactured this year are licensed under that single control patent. . . . The Lektophone Corporation has completed negotiations with Standard Telephones & Cables, Ltd., London, to represent the corporation in Europe.

—E. H. F.

A Resistance-Coupled Amplifier and Power Supply

By J. GEORGE UZMANN

Dubilier Condenser and Radio Corp.

HERE are the constructional details for a high quality audio and power amplifier together with a power supply unit which will supply B voltages to the r. f. amplifier with which it is used. If a.c. tubes are used in the r.f. and a.f. amplifier, the filament windings on the power transformer may be utilized for filament current, thus providing complete light-socket operation. The entire unit is one of good engineering practice as applied to both amplifier and power elements.

The combined unit was designed to meet the exacting requirements of an audio amplifier system which in itself should be capable of giving high quality reproduction; that is, this part of the assembly was expected to possess a fairly flat frequency characteristic over the range from approximately 50 cycles to about 5000 cycles. It was realized, of course, that the radio-frequency end of the receiver might appreciably alter this uniformity of audio-frequency characteristic.

Glancing at Fig. 1 and 2 it will be noted that the entire assembly of parts is such as to form several sub-groups; that is to say, the power transformer and filter condensers form one line-up; the rectifier tube, C-bias resistor and choke coils a second line; while a third group embodies a potential dividing resistor and bypass condenser network together with an anti-motorboating feature incorporated in the amplifier. The audio amplifier system makes up a final group assembly which, incidentally, is placed in a position as far away as possible from the transformer, so as to eliminate all stray field coupling. Further, the method of wiring largely helps in removing noise background from the audio output caused by stray fields, a.c. lines, etc.

Although the amplifier illustrated in this article employs d.c. type tubes, there is no reason why a.c. tubes cannot be used in the unit so as to make it completely a.c. operated; the filament windings on the power transformer may be used to supply filament current for the a.c. tubes. We have therefore indicated in Fig. 2 in dotted lines the circuit arrangement to use with a.c. tubes. No changes are necessary in the values of coupling resistors and the only additional parts required for a.c. operations are two resistors for C-bias, one with a value of 6000 ohms and another with a value of 1000 ohms. The a.c. tubes of course replace the type 340 and type 112 tubes and make it unnecessary to run C-battery or A-battery leads to the amplifier. For VT_1 we suggest the use of a CeCo type G high-mu tube. Tube VT_2 may be any standard type 227.

RESISTANCE-COUPLED amplification has not been used to any great extent in home constructed power amplifiers and its use in Mr. Uzmann's unit in combination with a push-pull output stage should prove interesting to many of our readers. Resistance-coupled amplifiers—properly designed—are noted for their excellent frequency response. The amplifier utilizes a circuit arrangement which prevents motorboating, a fault experienced with some resistance-coupled amplifiers and which has, in the past, perhaps made some builders hesitate to construct an amplifier of this type.

Storage battery type tubes are used in this amplifier because it was constructed before a.c. high-mu tubes were available, but tubes of this type can now be obtained from CeCo, Arcturus and others and may be used to make the amplifier completely a.c. operated. Their use in this amplifier is covered in the text of the article.—THE EDITOR.

THE AUDIO AMPLIFIER

THE audio amplifier system is made up of two stages of resistance coupling feeding into a high-grade push-pull output stage employing 310 type tubes. Such an arrangement generally fulfills the requirements of even the most exacting set owner.

This type of amplifier was adopted only after close study of the problem. It was felt that a properly designed resistance scheme of tube coupling in the detector and first audio stages would result in an amplifier having a flat characteristic, provided the number of high-mu tubes could be held at a minimum. For the latter reason either a 30 Mu or CX-300A tube should be employed as a detector, while a CX-340 high-mu tube is used in the first audio stage. A detector plate resistor of 100,000 ohms is suggested for the CX-300A detector, and a resistor of 250,000 ohms for the CX-340 tube. The grid leaks are of 2-megohm size.

Any three-stage audio amplifier system supplied from a common plate voltage source, and particularly from a socket power device, possesses characteristics which tend to throw such a circuit into audio-frequency oscillation—more commonly called "motorboating." In an effort to eliminate such a condition an anti-motorboating device was incorporated in the amplifier circuit. It consists of a 25,000-ohm wire wound resistor, R_2, connecting between the B plus 135-volt tap of the power supply and the detector plate resistor, together with a bypass condenser, C_3, of 1.0-mfd. capacity.

Incidentally, the audio input terminals of the amplifier do not include an r.f. choke and bypass condenser since it was believed that this practice is almost standard and usually included in the detector output. It is important, however, that such an arrangement be used.

The C-bias potential for the 340 tube, being small, is obtained by taking the voltage drop across its filament. For the second audio stage the bias voltage is obtained from a small external C battery.

A high-grade push-pull input transformer is used to connect into the CX-112A output circuit. The complete stage is of standard design and employs a push-pull output transformer, T_2. 310 type power tubes were adopted for this stage.

THE POWER SUPPLY SYSTEM

THE power transformer, A, has a tapped primary which readily permits of circuit adjustments suitable to meet varying line conditions without the necessity of variable resistors. Its high voltage winding outputs either 550 or 750 volts, making it suitable for a CX-381 type half-wave rectifier tube. For the audio and radio-frequency plate supply under discussion it will be found that the 550-volt tap is correct, otherwise the CX-310 plate voltage will be excessive and will result in poor tube life. Further, at this

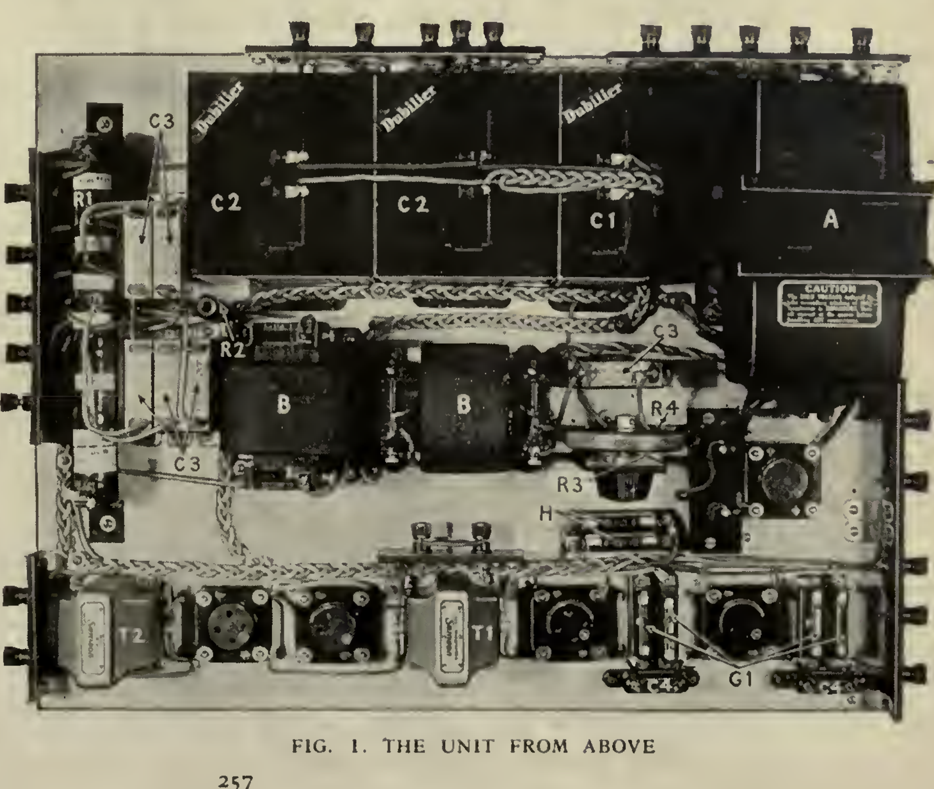


FIG. 1. THE UNIT FROM ABOVE

voltage the rectifier tube will be operated well under its maximum rated value.

The power transformer, because of its several low-voltage windings, also supplies a.c. filament voltage for the rectifier tube, the power amplifier tubes, for a number of 326 types, and also sufficient current for two 327 tubes—thus complete receiving set electrification is available.

C-bias potentials for the power amplifier tubes are obtained in quite the ordinary manner by means of the several bypassed wire wound resistors going to the mid-point tap of the transformer filament winding feeding the power tubes. A fixed resistor in series with one of variable type efficiently prevents one from accidentally cutting out the entire resistance and thereby operating the cx-310 tubes without a C potential, which would result in damage to both tubes.

THE FILTER NETWORK

THE filter network is probably the most important unit of a power supply system. In the apparatus under discussion the writer employed choke coils of high inductance and of a type which could be operated at high current densities without fear of loss of inductance, or possible core saturation.

Across the filter output is connected an efficient wire wound potential dividing resistor, R_1. Its total resistance amounts to 41,000 ohms and is tapped to provide the more commonly required B voltages. Each tap point is bypassed by means of condensers, as shown.

Some readers may want to use this power amplifier in conjunction with a dynamic type loud speaker. Loud speakers of this type can be obtained, designed to operate with a field excitation of about 60 milliamperes. This current can be obtained by connecting the field winding of the loud speaker in series with the filter system at the point marked X in Fig. 2.

GENERAL ASSEMBLY AND WIRING

THE preceding remarks may be considered in the light of the writer's idea of a set of specifications for building a high-grade power supply and amplifier system. And from it the reader may readily determine if the layout meets his requirements,

As to making up the general assembly no working dimensions are necessary, as Fig. 1 shows the best part arrangements, considered from an electrical viewpoint, and just where each piece of apparatus is to be placed on the 17″ x 21″ inch drafting board used for mounting purposes.

The wiring plan adopted is somewhat novel and seldom seen. It will be noted that a series of braided lead wires are employed throughout, and in final form it is apparent that a neat and workmanlike job results. The scheme is also one giving maximum insulation, since each lead is kept in a definite position with freedom from short circuits, broken connections, etc. High-grade rubber-covered stranded copper wire should be used for this purpose. The wire employed in the author's model was called "Rise Wire," made by the Belden Company; of course, any other equivalent type should prove suitable.

Perhaps the reader shall wonder what part is played by the several two-post terminal blocks. The block shown in Fig. 1 to the right of the resistor R_3 is merely a simple arrangement for feeding either 550 or 750 volts to the rectifier plate. A similar block will also be found facing the input push-pull audio transformer, T_1.

A jumper normally closes the latter terminals, since these happen to be in the grid return circuit of the power tubes. If a galvanometer is placed in this circuit we at once have a visual indication of the flow of grid current and, of course, such a condition simply means a distorted power output.

Connecting a high-resistance voltmeter across points Y and Z of the power tube C-bias resistors, as shown in Fig. 2, permits a correct voltage adjustment by means of the variable resistor. At a plate potential of 425 volts for the 310 tubes the normal resulting bias voltage should be 35.

The only nut-clamped connection of the set wiring will be found to be the lead wire going to the first choke coil. Connecting a milliammeter between these points permits taking a reading of the total direct current drain of the system. It is most important to determine that in no case should the plate voltage of the power tubes ever exceed 425 volts; filament voltages, both a.c. and d.c., should also be measured; in this way high quality reproduction and long tube life will be realized.

If the above instructions are carefully followed out, and the arrangement used as indicated, the amplifier will show an overall voltage amplification of about 3450 or a gain of 71 TU; while in terms of power amplification it is capable of producing up to 3 watts of undistorted energy. The maximum input signal voltage from the detector to produce maximum power output will not have to exceed 115 millivolts r. m. s., so there is no possibility that the detector will be overloaded.

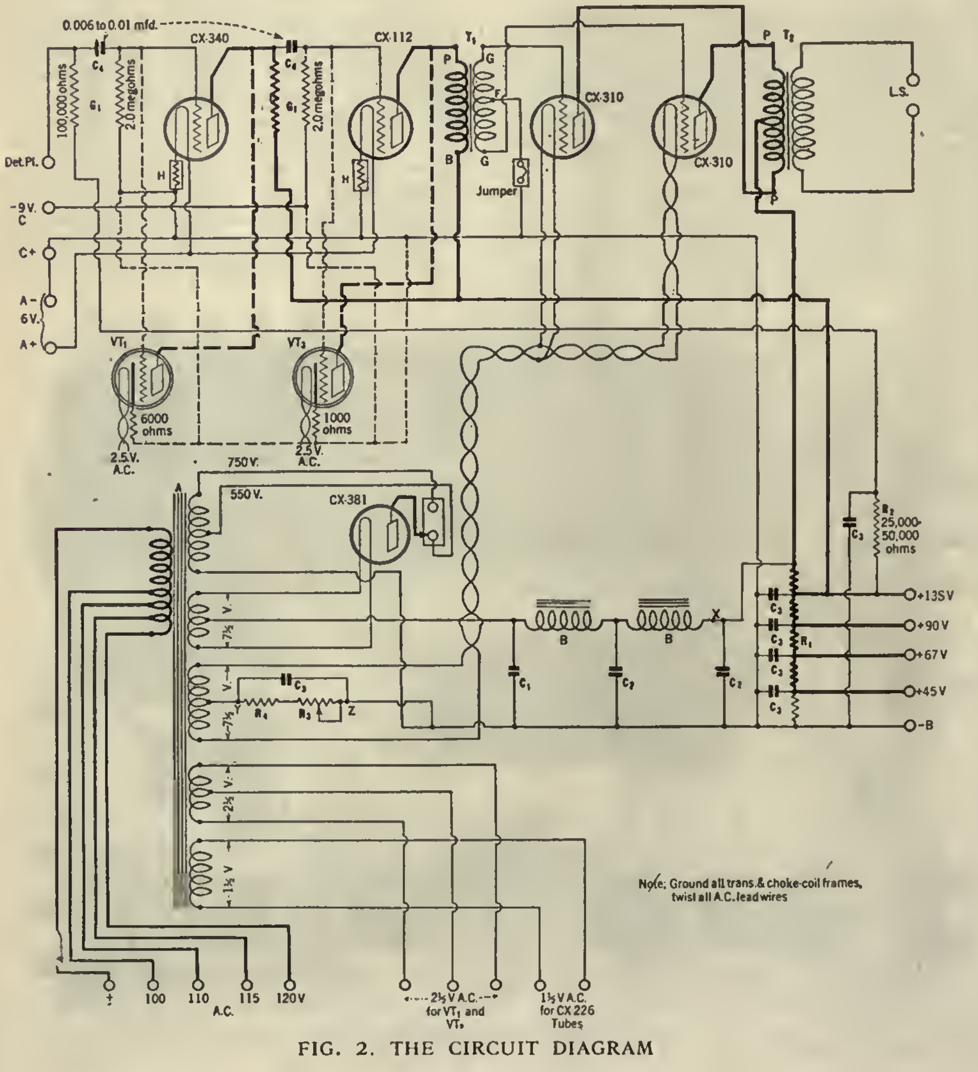


FIG. 2. THE CIRCUIT DIAGRAM

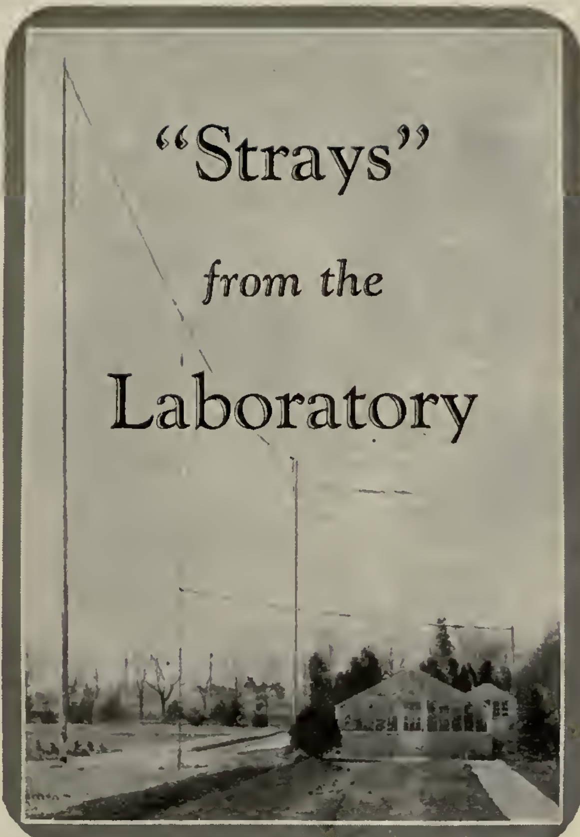
LISTS OF PARTS

THE parts listed below are those used in the particular unit described in this article, but since none of the parts are of special design there is no reason why the builder should not substitute for the parts indicated below, other units with equivalent characteristics. Frost, for example, makes wire-wound resistors that may be used for item R_1, and Centralab makes wire-wound resistors that can be utilized in place of resistor R_3.

- A —1 AmerTran power transformer, type PF281
- B —2 AmerTran choke coils, 20 henries, type 709
- C_1—1 Dubilier power condenser, 2 mfd., type 666
- C_2—2 Dubilier power condensers, 4 mfd., type 667
- C_3—6 Dubilier bypass condensers, 1 mfd., type 907
- C_4—2 Dubilier moulded Micadon condensers, 0.01 mfd.
- G_1—4 Dubilier Metaleak grid and plate resistors
- G_2—4 Daven grid leak mountings
- H —2 Amperites, 0.25 ampere, No. 1 A
- R_1—1 Ward Leonard AmerTran resistor, type 507-6
- R_2—1 Ward Leonard resistor, 25,000 ohms, type 507-65
- R_3—1 Ward Leonard Adjustat, 1000 ohms, type 507-7
- R_4—1 Ward Leonard resistor, 500 ohms, type 507-17
- T_1—1 Samson input transformer, type Y
- T_2—1 Samson output transformer, type 0-3
- 5 Benjamin 4-prong sockets
- 1 Mounting board, 17″ x 21″
- 7 Composition terminal strips
- Hook-up wires, screws, nuts, etc.
- 1 cx-340 tube (Ceco type G high-mu tube for a.c. operation)
- 1 cx-112 tube (cx-327 tube for a.c. operation)
- 2 cx-310 tubes
- 1 cx-381 tube

NOTE: A 6000-ohm and a 1000-ohm C-bias resistor are also needed, as shown in Fig. 2, if a.c. tubes are used in the a.f. amplifier

"Strays" from the Laboratory



Screen-Grid and Automatic Receivers

WE HAVE already published some data obtained in the Laboratory on several of the a.c. screen-grid tubes which are appearing on the market. The curves shown in Figs. 1 and 2 are taken from the *Arcturus Bulletin* and give interesting facts on the Arcturus tube of this type. The electrical characteristics are given below:

Heater potential	15.0 volts
Heater current	0.35 amperes
Control-grid potential	−1.0 volt
Screen-grid potential	30.0 volts
Plate potential	135 volts
Plate current	1.0 mA
Screen-grid current	0.50 mA
Amplification factor	400
Plate resistance	700,000 ohms
Mutual conductance	570 micromhos

The interesting fact, shown on Fig. 2, is the marked peak in the value of mutual conductance and amplification factor at minus 1-volt bias on the control grid.

From all appearances there will be few commercial receivers using screen-grid tubes available for some time. As usual the home constructor is still able to keep far ahead of the commercial receiver manufacturer; he still has better audio amplifiers than the majority of receivers, and he can build one of several kits now on the market using screen-grid tubes.

It is interesting to note that English set manufacturers are ahead of the Americans in the use of the screen-grid tube. The Marconiphone 61 uses three screen-grid tubes, each with a voltage amplification of 30—which amounts to about 27,000 before the detector—and a two-stage resistance-coupled amplifier which brings up the total voltage amplification in the receiver to about three quarters of a million. The entire receiver is copper shielded, each stage being carefully isolated from the others except through the proper conductances. In a loop ten by twelve inches in size, it is possible, in London, to bring in WJZ and WGY with loud speaker volume. Set Data Sheet No. 8, on page 278 of this issue of RADIO BROADCAST, contains more information on this interesting receiver.

The Radio Exchange receiver—also sold in England—uses two screen-grid tubes, has six sets of circuits each of which is permanently tuned to a given station and which is connected with a switch on which is engraved the name of the station.

At the Radio Trade Show in Chicago there were several screen-grid receivers, and at least one automatically tuned receiver, the Zenith. So far as we could see, there was little interest in the latter, although many people wanted to learn more about the screen-grid tube sets. We hope to present data on these receivers soon. The fact that few people seemed to care for automatically tuned receivers is but a commentary on the American's point of view—he wants to do his own tuning! The automatic tuning feature seems best suited to nickle-in-the-slot radios which will probably appear in pool rooms, cigar stores, ferry boats, chop suey joints, etc.

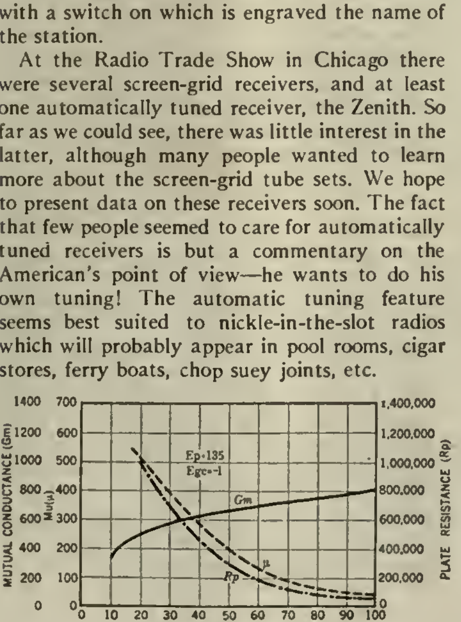


FIG. 1

Trailing "Power Leak" Interference

THE following letter from A. B. Chastian, Tulsa, Oklahoma, describes one source of what is usually called "power leak" interference, which may give many radio owners an opportunity to go through their own premises to see if occasional noises originate close to home in some unsuspected part of the house lighting system.

To the Editor:

You might be surprised to find your bothersome "power leak" interference very close at hand. Witness the following case:

A noise that sounded like a leak from wind blown wires scraping on a wet roof had been reported from widely separated points in the city. Because of the similarity of descriptions the trouble was believed to emanate from one source, but my part of it was traced to a swinging light fixture which had served for several years as both light and plug-in for various household appliances.

I did not suspect the lights for a long time, as the trouble would appear at any time, especially in wet weather, regardless of whether the lights were on or off. However, after much trouble shooting on an unusually damp day, in desperation I gave this fixture a gentle slap, and though it was turned off, the interference responded to the resulting motion of the fixture.

The old crumbly rubber insulation on the fixture wires was found to be chafed away in places by the metal parts of the fixture, causing a contact of high resistance which responded to weather conditions and vibrations of the room, sometimes as a loud continuous hum and again as an intermittent hum or sharp crackling.

Where interference sounds of this sort are heard, I would direct suspicion to any near-by fixtures, especially those having pull chain or key switches which jar the fixture when used. The joggling of the fixture chafes the insulation and causes these near-shorts, and in time will cause a real short that may prove dangerous.

More Radio Hoaxes

AFTER stating a number of complimentary things about RADIO BROADCAST, Mr. Ernest G. Kroger, Radio Operator on the *SS. J. L. Luckenback*, says, "I am particularly interested in 'Strays from the Laboratory.' That was a hot exposé of the output transformer in the July issue. I opened one I bought for $1.40 and found the same thing that you did. It carried the fancy name of 'Tone Filter.' Mr. A. H. Klingbeil's theory on fading due to street cars may be o. k. where he lives; maybe he can come forward now and give some explanation of fading on the high seas."

It is apparently Mr. Klingbeil's move.

While we are on the subject of radio hoaxes, we must congratulate *Radio News* on exposing the inner works and methods of sale of the Geppert "Kleer Tone" radio cure-all. We have already commented on devices that eliminated static, increased volume, increased d.x., and decreased the A- and B-battery consumption. In July *Radio News* the Geppert wave trap—selling at $4—is described, and as the editor states, better devices can be purchased for less than $1.

Another thing we should like to see exposed is the freak antenna, and we should like to get at the truth of this underground antenna business. Has anyone any data—not qualitative statements, but definite quantitative data—on relative signal strengths obtained from a 50-foot wire strung out in the open and the same length of insulated wire buried in the ground?

At Last—A Line Voltage Regulator

SEVERAL months ago we announced that automatic voltage regulator devices were soon to be on the market. The idea is to place one of these devices between the a.c. line and one's a.c. receiver or power supply or other apparatus requiring a constant input voltage. When the line voltage goes down, this device boosts the voltage, and when the line voltage goes up, the device reduces the voltage to that required by the receiver, let us say, and absorbs the additional voltage within itself. The data below is the result of a test in the Laboratory on the Acme Apparatus Company's unit.

Volts input from line	*Percent over-voltage*	*Output volts to 18-watt load*
96	−12.8	110
100	−9.1	110
110	0.0	110
120	+9.1	110
126	+14.6	110

Volts from input line	*Percent over-voltage*	*Output volts to 75-watt load*
94	−14.5	108
109	−1.0	109
123	+11.8	110

The device is designed to operate with apparatus requiring not over 60 watts, which would include all standard a.c. receivers getting fila-

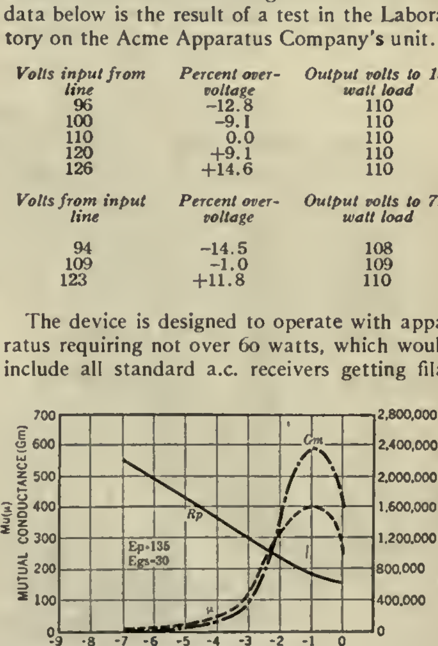


FIG. 2

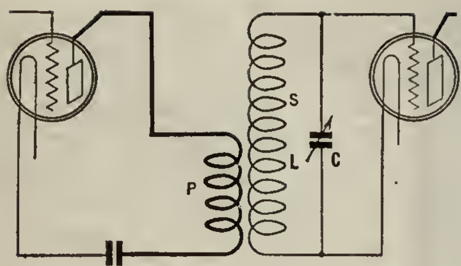


FIG. 3

ment and plate power from the house lighting lines. On a load of about 135 watts, the device did not regulate the voltage—but of course it was severely overloaded under these conditions, making the test unfair. The figures above are conclusive evidence that under the conditions for which the device was designed, almost perfect regulation is obtained by its use. We hope the Acme Company gets at least half the million dollar business we predicted for a device of this kind! It is the first such device tested in the Laboratory.

Some Coil Measurements

THE coils used in present day receivers control to a large extent both the selectivity and sensitivity of those receivers. All receivers with which we are familiar use the well known parallel tuned circuit—the "anti-resonant" circuit of the telephone engineers—shown in Fig. 3. The input to this circuit is usually a small coil acting as the primary, P, of a transformer whose secondary is the inductance, L, which is tuned by the variable condenser, C. The input of the following tube is placed across this shunt circuit.

The impedance of such a circuit, at resonance, is expressed as

$$Z = \frac{L^2\omega^2}{r}$$

where L is the inductance of the coil in henries
ω is equal to 6.28 times the frequency in cycles
r is the series resistance of the coil and condenser in ohms.

The impedance at any other frequency than the one to which the coil and condenser are tuned is lower than the above formula gives. At higher frequencies the impedance is essentially capacitive and low; at lower frequencies the impedance is inductive and low. Currents of other than the resonant frequency, then, do not build up such high voltages which may be applied to the following tube. Therein lies the selectivity due to such a tuned circuit. It will be increased as we decrease the series resistance. This is the reason for the "low loss" craze. A good coil-condenser combination is one which has little resistance in it and which has, therefore, a sharp resonance curve.

Since a resistance in *shunt* to this circuit has the same effect as a smaller series resistance, the tube resistance, R_p, of the previous tube tends to decrease the selectivity of the circuit, especially if it is connected across the entire coil. This is one reason why a step-up transformer is used. It may be looked at as a kind of selectivity transformer. Instead of shunting the entire tuned circuit with R_p, which may be 10,000 ohms, we step-up this resistance to about 200,000 ohms by connecting it across only part of the coil or through a small primary coil. Multiplying R_p by the square of the effective turns ratio, N, which usually amounts to about 20, adds a much lower effective series resistance in the circuit than if the 10,000 ohms were across the whole coil. The greater the mutual inductance, the poorer the selectivity; the fewer the number of primary turns, or the looser the coupling to the secondary, the greater the selectivity.

It is also true that the greatest voltage amplification will take place in such a system when the effective impedance in the plate circuit of the amplifier is equal to the plate resistance of the tube. That is, for maximum amplification

$$N^2 \times R_p = Z = \frac{L^2\omega^2}{r} = \frac{L}{Cr}$$

where N is the turns ratio of the transformer
R_p is the plate resistance of the tube
C is the capacity of the circuit

When these conditions are fulfilled, by means of the turns ratio of the transformer, the maximum voltage gain, K, is

$$K_{max} = \frac{1}{2}\frac{\mu}{\sqrt{R_p}} \times \frac{L\omega}{\sqrt{r}}$$

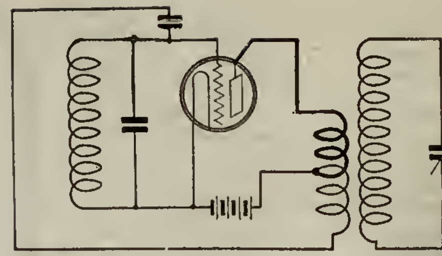
Under these conditions the series resistance of the tuned circuit is twice as great as it would be if the coil-condenser combination were unattached to the previous tube.

The expression K above may be divided into

TABLE 1

Coil	F k.c.	R ohms	L	D	L/D	Wire No. B & S	Turns inch	N	Ins.	Ind.
3″ slight spacing	550	4.1	1.09	3	.36	24	41	45	D.S.C.	170
	1000	6.5								
	1500	9.5								
3″ Hammarlund Roberts	550	3.1	1.69	3	.56	22	29	50	"	"
	1000	4.4								
	1500	7.1								
3″ Special	550	2.6	2.25	3	.75	22	23	52	"	"
	1000	3.7								
	1500	6.0								
Coil No. 1	550	7.2	1.44	2	.72	26	56	80	Enam.	240
	1000	11.1								
	1500	14.1								
Coil No. 2	550	3.9	2.63	2	1.31	22	34.5	76	D.C.C.	168
	1000	6.0								
	1500	9.0								
Coil No. 3	550	3.7	2.1	2	1.07	24	35	74	S.S.C.	170
	1000	5.7								
	1500	8.9								

Note. F = frequency in kilocycles
R = high-frequency resistance in ohms
L = length of winding in inches
D = diameter of coil in inches
N = total number of turns
Ins. = insulation
Ind. = Inductance in microhenries



Pat. No. 1,658,805

FIG. 4

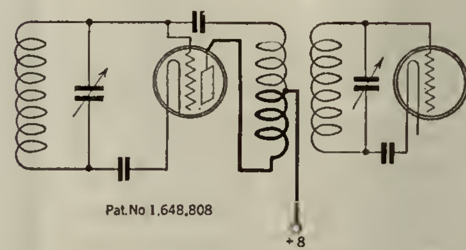


FIG. 5

two parts, one giving the amplification due to the tube $\frac{\mu}{\sqrt{R_p}}$ and the other giving the amplification contributed by the coil $\frac{L\omega}{\sqrt{r}}$

The factor due the tube is not the same as the mutual conductance, which is μ/R_p, nor is the coil gain factor equal to the "Q" of the coil, which is $L\omega/r$. The selectivity of the circuit, however, is more nearly proportional to "Q" and so this figure of merit of a coil is useful.

In Table 1, the first three coils listed are Hammarlund coils; the remainder are inductances of other manufacturers. This information is sufficient to enable anyone to calculate the "Q" of the coils, to estimate their selectivity factors, and to calculate the maximum voltage amplification that can be secured from a tube and coil-condenser combination of this nature.

The effect of coil dimensions, of the L/D ratio, of the spacing of the wires, and of the size of wire will appear in these tables. It has been known for a long time that the most efficient coil is one whose length of winding is equal to the diameter, and it is interesting to note how nearly this rule holds for the coils listed in the tables.

As has been pointed out in Professor Hazeltine's patent No. 1,648,808, reducing the primary turns to half the number required for maximum voltage amplification at resonance, reduces the resonant values only twenty per cent. compared to 50 per cent. at other frequencies. This means, of course, a material increase in selectivity. And in these days what everyone needs is selectivity!

Another Patent Muddle

THE diagram in Fig. 4 is taken from Patent No. 1,658,805, issued to Lester L. Jones, on a capacitive-coupling control system, dated Feb. 14, 1928 (original filed Dec. 15, 1922) and in Fig 5 is a diagram taken from Patent No. 1,648,808, issued to L. A. Hazeltine on a wave signalling system, dated Nov. 8, 1927, filed Feb. 27, 1925. We should like some technical minded reader to tell us how these differ. It will be a good test not only of one's knowledge of radio circuits, but of how patent lawyer's minds work. On the basis of Mr. Jones patent, suit was filed against the Freed-Eisemann Company and an authorized Stromberg-Carlson dealer some time in May, 1928.

KEITH HENNEY

No. 5 — Radio Broadcast's Home Study Sheets — September, 1928

Measuring the Amplification Factor of Vacuum Tubes

WITHIN the glass bulb of the majority of vacuum tubes used in receiving sets to-day are three metallic elements: the filament, which gets its voltage from the A-battery; the grid, which is connected to the radio circuit through a C-battery; and the plate, which takes current from the B-battery. Since each of these three voltages is variable, the actual operation of the tube is somewhat complex. The effect of varying the filament voltage has been determined in Home Study Sheet No. 3. (page 205, August RADIO BROADCAST). We shall now fix this voltage at some definite value, and notice the results of varying the other two voltages, one at a time. The apparatus needed will be as follows:

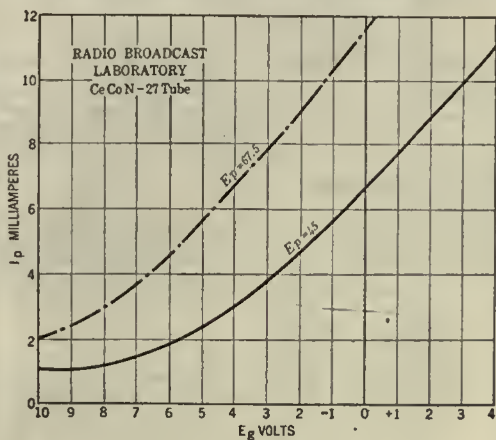


FIG. 1

LIST OF APPARATUS

1. The baseboard set-up used in Experiments No. 3 and No. 4.
2. A source of filament current, say a 6-volt storage battery.
3. A C-battery with taps at 1.5, 3.0 and 4.5 volts.
4. Two B-batteries with taps at 45, 67.5 and 90 volts.
5. A milliammeter reading up to 10 milliamperes. A Weston Model 301 5-milliampere meter was used in the Laboratory. A low range meter with the proper shunts may be used.
6. A filament resistor to reduce the 6 volts from the battery to the proper value for the tube, 5 volts. A rheostat or fixed resistor of the proper value may be used.

PROCEDURE

Connect up the apparatus in the following manner, as shown in Fig. 2:
1. Plus A to one end of the filament resistor.
2. Clip 1 to other end of resistor.
3. Minus A to clip 2.
4. Minus B to clip 2.
5. Plus C to clip 4.
6. Milliammeter between clips 6 and 7.

Connect leads with Eureka or similar clips on one end to terminals 5 and 8. These will enable the C and B voltages to be changed quickly and easily.

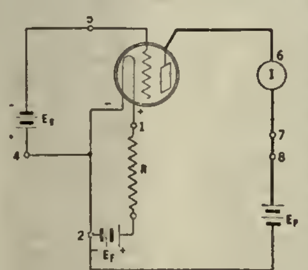


FIG. 2

If fresh B and C-batteries are used it will not be necessary to measure their voltages, and under any conditions we are more interested in the effect of varying these voltages than in their exact values. Inasmuch as the characteristics of two tubes of the same type from the same factory differ slightly, it is not necessary to know the C and B voltages with great precision.

Make the grid negative by placing the wire on clip 5 on the minus 4.5-volt tap of the C-battery. Read the plate current when the plate lead, clip 8, is placed on the 22.5 or 45-volt tap of the B-battery. Now increase the B voltage in steps up to 90 and then repeat the measurements with different values of C voltage, say minus 3, minus 1.5, zero, and plus 1.5 volts. Set down the data in the form shown in Table 1 which is the result of measuring a Ceco heater or 27 type of tube. Zero C voltage is obtained by connecting clip 5 to minus A or clip 2. Plus C voltages are obtained by reversing the C-battery connection, that is, connecting minus C to clip 4.

Now take data by changing the C voltage or bias, keeping the B voltage fixed. That is, fix the plate voltage at, say 45 and read the plate current as the grid voltage is changed from minus 4.5 to minus 3, etc., until the plate current is too great for the milliammeter to read. This data is tabulated in the form shown in Table 2. The data from these two tables should now be plotted as shown in Figs. 1 and 3.

DISCUSSION

The electrons which boil out of the filament when it is heated by the A-battery current flowing through it are negatively charged. The plate, which is charged positively by the B-battery, has a very strong attraction for these electrons. They, therefore, hurry toward the plate carrying with them their electric charges. If a certain number, 6.8×10^{18} per second, arrive at the plate, the flow of current out of the B-battery, through the plate current meter, and back to the negative side of the filament—where this part of the plate circuit is attached—is equal to one ampere. In receiving tubes the current is of the order of thousandths of amperes, or 6.8×10^{15} electrons per second. The greater the plate voltage, the greater the number of electrons that arrive per second. Consequently the greater is the plate current.

Between the plate and the filament is the grid, a sort of turnstyle which regulates the number of electrons that get past it. How? The voltage of this grid can be made positive or negative with respect to the source of the electrons. If it is negative, it tends to repel any electrons that come along on their way to the plate. They must either return to the positive side of the filament, or float around in the space between the grid and the filament. Some few of them get through to the plate. If the grid is made positive, it accelerates the flow of electrons from the filament, and either attracts a number of them to itself, producing a flow of current in the grid circuit, or hastens them on their way toward the plate.

Since the grid is closer than the plate to the source of electrons, it has a greater effect on their rate of travel. The relative effect of grid and plate upon the plate current is called the amplification constant (the symbol is the Greek letter mu, μ) and is determined from the above data in the following way. Let us consider the I_p-E_p curve in Fig. 3, which represents the variation of plate current with variation of plate voltage. Choosing values from the curve for E_g = minus 3, we note that at 67.5 volts the current is 7 milliamperes and at 50 it is 4 milliamperes. Thus a change of 17.5 plate volts causes a change in plate current of 3 milliamperes. Now the question arises, what change in grid voltage will cause the same change in plate current? Looking at the 67.5-volt curve of the I_p-E_g graph (Fig. 1) showing how the plate current changes with grid voltage changes, we see that at zero grid volts the plate current is 11.5 milliamperes and at minus 2.3 the plate current is 8.5 milliamperes. This represents a plate current change of 11.5—8.5, or 3 milliamperes caused by a grid voltage change of 2.3 volts. From these figures we can determine mu.

The amplification constant is calculated then as follows:

$$\text{Mu} = \frac{\text{change in plate volts}}{\text{change in grid volts}} \text{ to produce a given plate current change,}$$

$$\text{or} = \frac{67.5-50}{2.3} = \frac{17.5}{2.3} = 7.55 = \text{mu}$$

The important thing to note here is that it is the *change* in voltages that must be divided by each other, not the actual voltages at any particular point. These changes in voltages may be reckoned only over that part of the I_p-E_p and I_p-E_g curves which appear to be straight lines. The smaller the length of these straight lines that are used in our calculations, the greater will be the accuracy with which the value of mu will check that obtained on an accurate vacuum tube bridge.

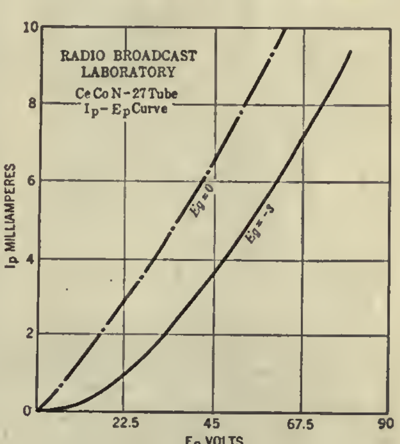


FIG. 3

PROBLEMS

1. Plot all of the data in Tables 1 and 2, and calculate the amplification factor at a number of points on the curve. Plot these values against plate voltage and then against grid voltage.
2. Calculate the value of the resistor needed to cut down the A battery voltage, 6, to the voltage required by the filament, 5.
3. Repeat the above experiment for other types of tubes in your laboratory.
4. Should the I_p-E_g curves be steep or flat for a high-mu tube? For a power tube?

TABLE I

Data for E_p-I_p curves

E_p = plate volts	Grid volts: 0	—1.5	—3.0	—4.5	+1.5
	Plate current (I_p) in mA.				
0					
22.5	2.8	1.5	1.0	.5	3.8
45	6.4	4.7	3.5	2.4	7.6
67.5	10.4	8.5	7.0	5.5	11.0
90			11.0	9.4	

TABLE 2

Data for I_p-E_g curves

E_g = grid volts	Plate voltages: 22.5	45	67.5	90
	Plate currents (I_p) in mA.			
—10	.25	1.0	2.0	6.0
— 8	.3	1.2	3.2	7.0
— 6	.4	1.8	5.3	8.5
— 4	.55	3.0	6.6	11.0
— 2	1.4	4.7	8.8	14.0
0	2.9	6.8	11.5	17.0
+ 2	4.5	8.7	14.0	19.5
+ 4	6.2	11.0	16.5	22.0
+ 6	8.0			
+ 8	10.0			

No. 6 Radio Broadcast's Home Study Sheets **September, 1928**

Vacuum Tube Characteristics

THE three important factors governing a vacuum tube's operation in a radio circuit are:

1. Amplification Factor, $\mu = \frac{\text{change in plate voltage}}{\text{change in grid voltage}}$

to produce a given plate current change.

2. Plate Resistance, $R_p = \frac{\text{change in plate voltage}}{\text{change in plate current}}$

or, the effect upon the plate current of changes in the plate voltage.

3. Mutual Conductance, $G_m = \frac{\text{change in plate current}}{\text{change in grid voltage}}$

or, the effect upon the plate current of changes in grid voltage.

Home Study Sheet No. 5 gives sufficient data to determine all of these factors.

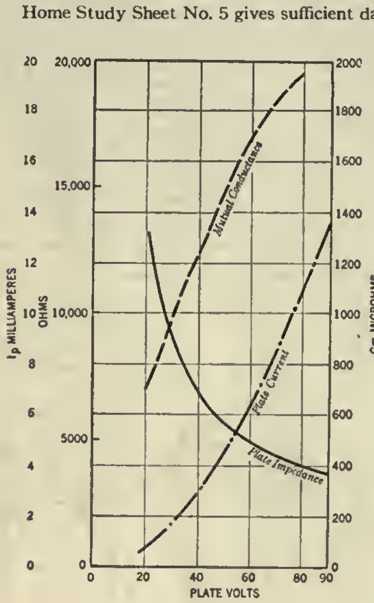


FIG. 1

Note: The word *microhms* at the right on this diagram is an error. It should be *micromhos*

The plate resistance, sometimes called the internal resistance or impedance of the tube may be determined by dividing a change in plate voltage by the corresponding change in plate current it produces. Care must be taken to use the proper units, that is, volts must be divided by amperes—not milliamperes. For example, let us determine the impedance of the tube used in Sheet No. 5 at minus 3 volts grid bias. We look at Fig. 3 on Sheet No. 5 and see that at minus 3 volts the plate current is 7 milliamperes when the plate voltage is 67.5 and about 3.5 milliamperes when the plate voltage is 45. Then,

$$R_p = \frac{67.5-45}{.007-.0035}$$

$$= \frac{22.5}{.0035} = 6457 \text{ ohms.}$$

This resistance varies with each change in plate and grid voltage. When it is determined by the above method, small changes in plate voltage should be used. More accurate results would be obtained if changes of ten volts were used instead of 22.5. At low plate voltages the plate resistance is relatively high and as the plate voltage is increased the plate resistance decreases, rapidly at first and then more slowly as the normal operating voltage is reached. This term "plate resistance" is a measure of the plate circuit's resistance to the flow of alternating current. The resistance of the plate circuit to the flow of direct current is equal to the voltage on the plate divided by the d.c. plate current in amperes. For example, in Fig. 3, Sheet No. 5, we see that the plate current is 7 mA when the plate voltage is 67.5 volts and the grid bias is minus 3 volts. Therefore the d.c. resistance of the plate circuit is

$$\frac{67.5}{0.007} = 9{,}643 \text{ ohms}$$

The mutual conductance may be determined by noting the effect on the plate current produced by a given change in grid voltage. Looking at Fig 1, Sheet No. 5, we note down the following data taken from the point where the plate voltage is 45.

$$\frac{\text{Change in plate current}}{\text{Change in grid voltage}} = \frac{.0064 - .0035}{3 - 0}$$

$$= \frac{.0029}{3} = .00097$$

The unit of conductance is the mho, so the above value is .00097 mhos, or as usually stated, 970 micromhos. This shows that with 45 volts on the plate of this tube a change of one volt on the grid in the region between minus 3 and zero produces a change of 970 microamperes plate current. This may also be obtained by determining the slope of the I_p-E_g curve in the vicinity of minus 3 volts. (See Home Study Sheet No. 4, for a definition of the term "slope".)

The mutual conductance varies with each value of plate and grid voltage, and will be more representative of what the tube actually does in a radio circuit if small grid voltage changes are used to determine its value.

The amplification factor may be found as in Sheet 5 or by multiplying the plate resistance in ohms hy the mutual conductance in mhos, since a little juggling of the above formula for these values shows such a relation to exist, that is $\mu = R_p \times G_m$

PROCEDURE

Determine the plate resistance and mutual conductance for several values of plate and grid voltages, taking the data from that obtained in Sheet No. 5. Plot these values as shown in Fig. 1 and Fig. 2.

Determine the values of plate resistance and mutual conductance by taking the slopes of the curves at the proper points, and see how nearly these values check. (Note: The term "slope" was explained in Sheet No. 4.)

DISCUSSION

The curves made by plotting the data secured in the experiment in Sheet No. 5 are known as static characteristic curves, and the values of M_u, R_p, and G_m are called the static characteristics of the tubes under test. They tell us all we need to know about a tube to predict what it will do in nearly all kinds of electrical circuits.

The amplification factor gives us an idea of what happens when a small voltage is impressed on the grid. This voltage reappears in the plate circuit of the tube, multiplied by the amplification factor. For example if the tube has a mu of 8 and a signal with a value of one volt is impressed on the grid, then there appears in the plate circuit a signal with exactly the same form as that impressed on the grid, but with a value of eight volts. In bridge methods of measuring the mu of a tube, a voltage is introduced into the plate circuit which is opposite in direction to that appearing there due to the input voltage to the grid. When this opposing voltage in the plate circuit is equal to mu times the grid voltage, the two voltages cancel each other and silence is obtained in a pair of headphones. The mu of a tube is practically constant over the entire range of operating voltages, as can be seen by refering to Fig. 2 on this sheet. The other constants of a tube vary considerably with the applied plate and grid voltages.

The mutual conductance of the tube tells us how great a change in plate current will occur if the grid voltage is varied. For example, if the G_m of a tube is 600 micromhos a volt a.c. input to the grid will produce an a.c. current in the plate circuit of 600 microamperes. This change in current may be used to set up a new voltage which may be again amplified by succeeding tubes.

The plate resistance of the tube gives us an idea of what happens to these plate current changes produced by grid voltage changes. If the tube had no resistance, all of the a.c. plate current would be useful across the coupling device in the plate circuit of the tube. Since, however, the tube has a resistance, this a.c. current must flow through not only the coupling device, but through the plate resistance as well.

If the plate resistance of the tube is 30,000 ohms and the coupling resistance has a value of 60,000 ohms then the total signal voltage in the plate circuit is divided into two parts, two-thirds of the voltage appearing across the coupling resistance and one-third across the plate resistance. The total a.c. voltage developed in the plate circuit is divided between the load, or coupling device, and the tube resistance.

If a coupling device is used which has considerable resistance, the voltage actually on the plate is not the same as the B-battery voltage but is less by the drop in voltage across the coupling resistance; the voltage drop being determined by ohm's law. See Home Study Sheet 4, August Radio Broadcast.

The amplification factor of a tube varies inversely as the spacing between the wires forming the grid and directly as the distance between the plate and filament and between the grid and filament. Thus to obtain a tube with a high amplification constant it is necessary to use a fine mesh grid mounted close to the filament, as compared to the distance between the plate and the filament.

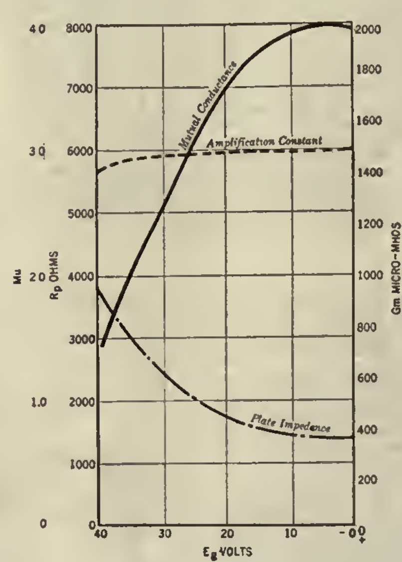


FIG. 2

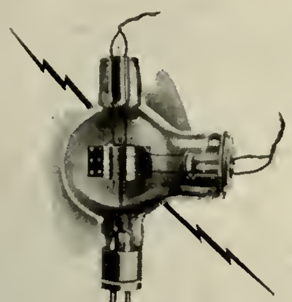
PROBLEMS

1. Suppose you are to design a series of tubes, each with a mutual conductance of 500 micromhos. Plot a curve showing how the plate resistances and amplification factors of these tubes will be related.

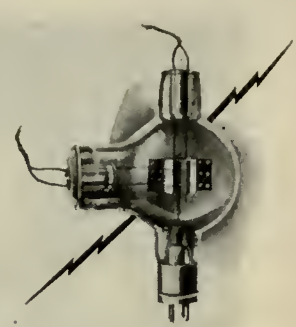
2. Suppose a tube had a 55,000-ohm resistor in the plate circuit, that one milliampere of current were flowing, and that the B-battery voltage were 90. What is the voltage actually on the plate?

3. Suppose you had a tube with a mu of about 30, and a plate resistance of 60,000 ohms. What is the mutual conductance? If the plate current is one milliampere, how much B-battery voltage will be required to put 90 volts actually in the plate, if a coupling resistor of 250,000 ohms is used?

4. The curve in Fig. 1 does not have the values of mu plotted on it. Calculate these values and plot. What kind of tube do you think it is?



Working on 5 Meters



By ROBERT S. KRUSE

THE preceding 5-meter story in August Radio Broadcast told of the ancestry, birth and childhood of the 5-meter band. All biographies are required to have such a first chapter, which the author expects the reader to skip. The reader usually does skip it; everyone is satisfied and ready to begin the main story, which shall happen here and now.

Since this present story is to undertake the large job of describing a complete radiophone or c.w. circuit operative at a wavelength of 5 meters (60,000 kilocycles, if you like bulky terms) we must needs proceed logically or become lost. It seems simplest therefore to start with the transmitter and proceed via the sending antenna, receiving antenna, receiver and headset to the Receiving Experimenter. It is hoped that this will leave over enough time to go back and see what curious things the wave has done en route.

THIS is the second of Mr. Kruse's articles to appear in Radio Broadcast, *supplying experimenters with data on transmission and reception on 5 meters. Now that the bread has been cast upon the waters, the editors and Mr. Kruse are anxious to know who is gathering in the loaves. We would like to hear from all of those to whom the articles have proved interesting. If you have done or expect to do any work on 5 meters—or if you are doing any work at all on short waves—drop us a note telling what you are doing and what material you would like to see published in future issues.*

—The Editor.

THE TRANSMITTER

IT SEEMS like obvious nonsense to say that the business of the sending set is to generate a decent phone or c.w. signal, yet the average operator or experimenter never seems to think of this. He is perfectly happy if the meter in the antenna circuit moves far across the scale. That the speech or code being transmitted cannot be "unscrambled" seems to him to indicate that the man at the other end is distinctly dull and incapable.

This is then a plea for more than the usual attention to proper transmitter operation, whether the output carry speech or dots and dashes.

The usual way of getting at the 5-meter business appears to be that of "sneaking down on the wave." This unfortunate habit has just received new impetus by the opening of the amateur band of 10-10.7 meters, which is unfortunate for 5 meters, since the 10-meter band can be worked with normal circuits in the transmitter while 5 meters demands changes. The former therefore has little educational value toward learning to handle 5 meters.

The first requirement of the 5-meter circuit is of course that it work at 5 meters, the second that it do so steadily and the third that the apparatus be neither too special nor too anxious to "blow up" in operation. All of these needs are met by the circuits shown in Fig. 1. Little explanation needs to be made other than that provided by the caption of the figure, except in the case of the modulator, D. When telephony is desired this is interposed between the B supply and RFC_1 of any of the circuits shown. If the oscillator is a ux-210 or a uv-202, the modulator will be a similar tube and the transformer a modulation transformer. The C-bias on the modulator must be adjusted by ear until decent speech results. If such speech cannot be obtained the microphone or the transformer are to be suspected. If once abused many microphones never recover; on the other hand, many of the modulation transformers now available cannot operate properly with the normal microphone current flowing through them—having been designed for the costly double-button microphones or for some weird sort of "mike" that cannot be found on the market.

If the oscillator tube is of a larger sort, such as the ux-852 or the uv-204A we must use the same sort of tube as a modulator. Naturally such a tube cannot be operated directly from the modulation transformer; therefore we must put a stage or two of audio amplification in between to boost the gain to get a decent percentage modulation. Any good audio amplifier can be used. One has only to remember that the microphone can operate a 112A tube very nicely but that its plate current is a bit high for the average audio transformer; therefore the 201A is a good first tube when used with 90-135 volts and the appropriate bias. The second tube may be a 171 or a 210 and the third tube a 210 or an 852. In each case the last tube should be fed by the next smaller tube, but one can stand a jump from a first-stage 201A to a second-stage 210. Biases are in general a bit higher than for ordinary amplification and things are improved all around if there is a control in the shape of a 500,000-ohm Frost rheostat across the secondary of the first audio transformer. If at any point in the circuit it seems not possible to find a transformer to fit the job one can always rig up an impedance-capacity-impedance coupling as shown at E. The iron core choke in the B lead must be designed liberally enough to carry the plate current of the tube and have an inductance of at least 6 henries, while the condenser at its base should have a capacity 1 or 2 mfds. The grid choke going to C- can be almost anything, since the current is small. An audio transformer primary or secondary will serve if left on the original core.

STARTING THE OSCILLATOR

BEFORE the modulator is connected to the oscillator the latter should be working properly. This is easily found out by touching almost any part of the tuned circuit with an Eversharp pencil (advt.) while holding on to the metal parts of the pencil but staying well clear of any other metal work whatever, *especially* any electrical circuits. If the tube is oscillating the characteristic fizzing will appear at the point of the "lead." A bit of metal such as a screwdriver will serve if nothing better is available. The bare finger will do but takes time to heal.

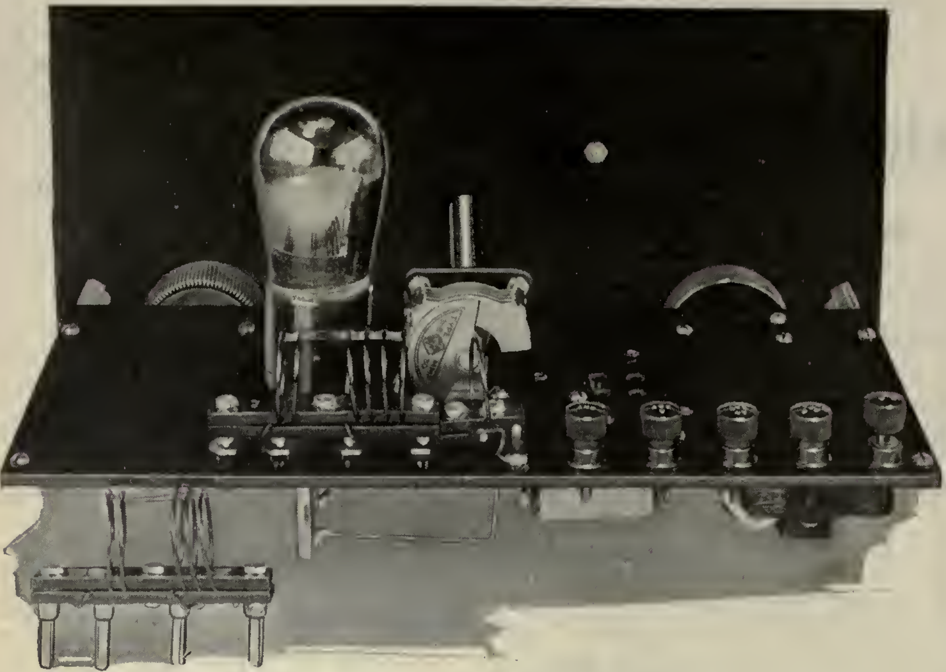
If the tube refuses to oscillate it can frequently be caused to start by changing the points at which RFC_1 and RFC_2 are connected to the tuned circuit, or by changing these chokes themselves or backing them up with other chokes. If this does not do the work one may change the grid bias or temporarily shift the adjustment of C_1 to a higher wavelength. Usually 5-meter oscillators using a ux-210 or a ux-852 give little difficulty. In fact the 852 was designed for just such work.

Having the oscillator in operation one next adjusts for reasonably steady operation and then with the aid of a General Radio 5-meter wavemeter gets the wave right. The further adjustments must wait until the receiver is ready, though we may get the sending antenna up meanwhile. Figure 2 shows some suitable antennas of which the types shown for the Phelps station and the West station are simplest and therefore recommended as desirable for the beginner in 5-meter work. One can gauge the proper length for any antenna system shown here or elsewhere by remembering that for each half-wavelength we will need roughly 100 inches of antenna. Thus the West antenna system must be about 100 inches long minus something to permit use of a coupling coil, while the Phelps arrangement can have almost any convenient length if a little loading, consisting of a few turns of wire, is done at the base. A length of 500, 700, 900 or 1100 inches works out well. The work at 2EB has been done to a large degree with the last of these lengths. In any case one *must* keep the antenna well away from things—trees, wires, hanging flower baskets, etc.—for absorption is severe at 5 meters. Depending on the combination chosen, one tunes the sending set up by setting the primary wavelength, i.e. the "tank" circuit, correctly with the General Radio wavemeter and then adjusting the antenna tuning condenser or cutting pieces off the antenna until the proper wavelength is obtained. In the Phelps arrangement in Fig. 2, one cannot well climb the mast to cut pieces off the antenna, so the adjustment is made by resetting the sending set condenser, C_1, and by using a loading coil of the proper number of turns at the base of the antenna.

When the lamp in the antenna glows steadily or the meter returns to the same reading promptly each time the plate supply is closed we are done for the time and can move on to the receiver.

THE RECEIVER

IT IS perfectly possible to build a 5-meter receiver with a stage of r.f. amplification using the ux-222 screen-grid tube, but the result is a receiver with two tuning controls, and until



A MANUFACTURED 5-METER RECEIVER

This receiver is of the detector-audio type, and is made by Parmeter Products, of Lansing, Michigan

one has a little practice in 5-meter reception and has gotten the sending set steadied up such a set is of little practical value because of the difficulty of following the transmitter wave—or finding it initially.

If radiophone is to be received the best device is certainly the double-detection receiver, and as second choice the regenerative detector with audio amplification, to which the stage of 5-meter r.f. may be added later. The perfectly commonplace circuit of such a 5-meter set was shown in the August RADIO BROADCAST article.

For c.w. reception we have a much more powerful tool in the form of the double-detection receiver which is shown in diagrammatic form in Figure 3. This consists simply of an oscillating detector ("autodyne") followed by an i.f. amplifier and a second detector with a single stage of audio. To secure a beat note from the c.w. signal there is provided a long-wave (intermediate frequency) heterodyne which beats upon the intermediate frequency. This heterodyne may be removed and a 5-meter heterodyne put in whereupon the set becomes suitable for 5-meter phone work. The first detector in such a case is left regenerative but not oscillating. However as it stands the set can receive phone in a somewhat "chewed" manner by careful adjustment of the first detector and removal of the tube from the heterodyne oscillator socket.

A further improvement is to replace the i.f. amplifier shown in Fig. 3 by a single UX-222 tube with a band-pass filter either before or after the UX-222.

MAKING THE RECEIVER WORK

THE troubles of a 5-meter receiver are those of any regenerative receiver or double-detection receiver plus the additional job of persuading the tube to oscillate without howling at 5 meters. The solution of this begins in making the receiver oscillate at all, and ends in eliminating the yelling. Usually it is easiest to start at about 7 meters, guessing at the proper coils, and then work down gradually to such dimensions as mentioned in connection with the receiver. Do not take the dimensions too seriously since such a trifling thing as a change in the make of socket may demand an entire turn to be taken off the coil. It is therefore a matter of "cut and try," with constant attempts to find a click or thump on the General Radio wavemeter by turning its dial slowly while it is held near (1" to 1') the tuned system and the phones are worn around the neck or otherhow far enough removed from the ears to prevent damage from a sudden savage scream. Changes in the tickler diameter, number of turns and location, together with alterations in the grid leak and filament current will finally produce a combination which can be taken in and out of oscillation quietly and at the same time has the proper range of tuning. It is well to spend an evening or two in getting this strictly right, after which the regeneration control condenser, C_2, should be left severely alone to prevent changes in calibration. Use the rheostat, R, to control the regeneration thereafter. In general it will be found best to use a tickler (L_2) which is rather close to L_1 and has turns between one half and three quarters of the diameter of L_1 made of a wire fine enough to handle easily when making changes but not "floppy." Both L_1 and L_2 should be substantially secured into position to avoid vibration noises. On the other hand the UX-112A tube must be mounted in a springless socket set on sponge rubber and fed by wires of the greatest softness, such as small bare or silk covered single strands of No. 30. These wires must be kept mutually apart since changes in their separation will cause noise and loss of signals. The filament wires need not be handled so carefully, but the grid and plate wires should depart at something like right angles from each other so that motion will not change their separation greatly. The grid leak and condenser may be mounted on the tuning condenser with a flexible lead to the socket, or on the socket with flexible leads to the tuning condensers. Leaks of a value above 8 megohms or below 1 megohm will work about equally well.

THE RECEIVING ANTENNA

HAVING caused the receiver to oscillate decently and smoothly we may now connect it to an antenna and see if it will continue to perform decently. Here we find from experi-

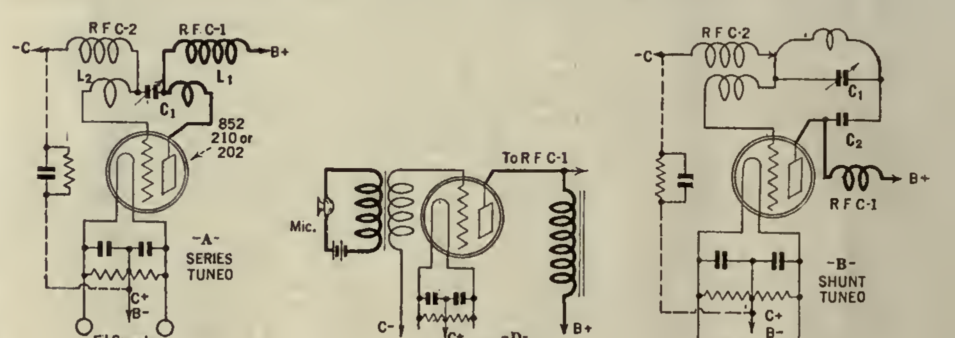


FIG. 1. TYPICAL TRANSMITTING CIRCUITS

All these circuits are of the ultraudion type. They operate smoothly after the chokes have been made correctly. As a starter these may be wound with No. 36 d.s.c. or s.c.c. wire spaced slightly on a ¼" form about 2" long. Sometimes a foot of small wire stretched out straight is almost as good. The center taps consist of double 100-ohm resistors with each half shunted by a capacity of about 0.001 mfd. The filament leads may be choked to advantage outside the diagram. For the tuning circuit, L_1, L_2, one may start with a total of 3 turns of 3" diameter in circuit A and a condenser, C_1, of 100 mfd. maximum. For circuits B and C the capacity, C_1, need not be above 25 mmfd. and the entire inductance from grid to plate need not be over a foot long. C_2 in B and C can be anything around 200 mmfds., capable of withstanding the plate voltage. Make good connections. Ordinary grid leaks make trouble and a grid leak and condenser consisting of two aluminum wires immersed 1" in water is a good thing to use. Changes may be made; the inductance of A may be a single turn 10" across. The chokes in these diagrams are not coupled to the tuning coils.

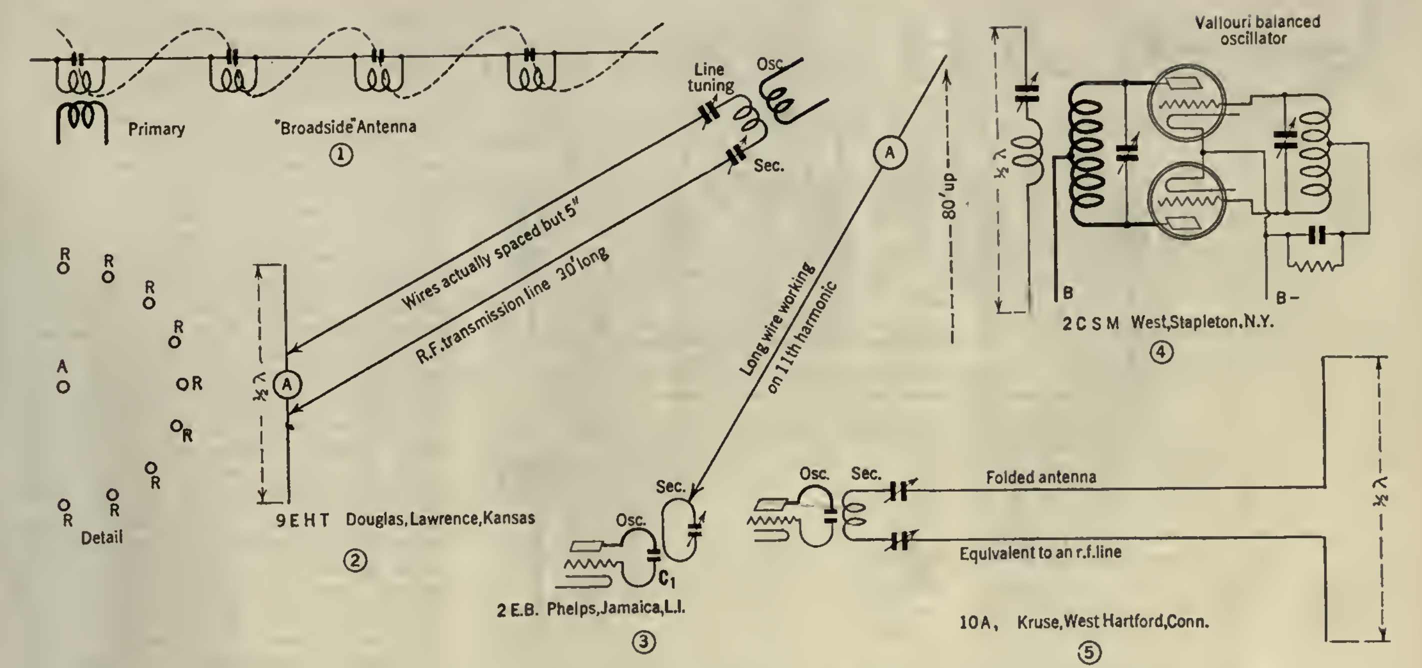


FIG. 2. TRANSMITTING ANTENNAS FOR 5-METER WORK

The Douglas antenna was equipped with the feeder system shown in the diagram to permit its erection a long way from the badly screened station. The "detail" shows a cross-sectional view of a reflector system occasionally used with this antenna. The circle A represents the antenna and the circles RRR represent reflector wires parallel to the antenna and arranged in an approximate parabola. The number and placement of the wires, R, was varied. The whole arrangement can be laid on its side to become a horizontal system.

The West antenna is a normal ½-wave antenna with a coupling and tuning system at its center. The condenser needs but two plates. The system is roughly 90 inches long, counting the coil length. The balanced Vallauri oscillator needs no r.f. chokes.

The Phelps antenna is voltage fed at one end by a tuned circuit coupled to the oscillator. The antenna ammeter, A, is 50" from the high end.

The "broadside" antenna consists of a series of 100" half-wave antennas connected by 5-meter tuned circuits. All of the half-wave sections operate almost in phase and give broadside transmission almost like that of Marconi's beam stations.

In all the diagrams "osc" is the oscillator as shown in Fig. 1. In all cases the inductance and capacity in the secondary circuits must be such as to tune to 5 meters.

ence that a long wire such as is normally used for broadcast reception is as good as anything. It may be connected to the coil, L_1, as suggested in the diagram of the double-detection receiver (Fig. 3) or may be given a separate primary. There seems to be little choice. The antenna series condenser, C_3, when used, consists of a "vernier" condenser with all but one fixed and one movable plate removed. If the attachment of the antenna to the set stops oscillation one may be sure that the antenna is too closely coupled. It should then be clipped on nearer the filament end of L_1, the setting of C_3 made smaller, or the primary coil (if any) put farther from L_1.

RECEPTION AND TRANSMISSION

HAVING the apparatus all together with some current in the sending antenna and some sign of proper action on the part of the receiver, we are ready to try communication by radio to supplement the letter communication that has previously taken place with other 5-meter experimenters.

Before going on with this it is well to make sure of the thing first preached about—that the set really turns out a signal that it is possible to make head or tail of. To do this the sending set is put into action with some kindly neighbor or friend to punch the key or talk into the "mike" and the receiver is set up in another part of the house or perhaps in the front yard. The friend or neighbor had better be warned that he is in for a session of several hours and must not get impatient at the long silence that opens the proceedings.

First of all the receiver will probably take a notion not to oscillate, though there is no real justice in this as it does not have an antenna at the moment. The second discovery is probably in the nature of noise in the receiver, or unsteadiness at the transmitter which must be remedied. However, be of good heart—it is far easier to do this than to go through the silly performance we staged. We did not take the precaution just suggested and when our first sets were in operation we spent a month or so in listening at 120 miles for signals that eventually turned out to be wholly in the Choctaw language.

Eventually the transmitter and the receiver will be gotten into decent shape and will agree to work on a sporting basis—half the time. Then one is ready to take the field.

WHAT CAN BE DONE AFIELD

BEFORE another transmitter is available to work with, one may do some very enchanting things near the station by wandering about with receiver, wavemeter and screwdriver, testing for the manner in which the radiated power is scattered about the vicinity—which is usually surprising enough.

These tests require the set to run while the owner is absent, and as the patience of the friend or neighbor was exhausted in the first tests one must make up an automatic key of some sort. C. H. West of station 2CSM created some sort of an affair from an alarm clock and a relay which made dashes for hours at a time and later drove a disc with the station call on it. He says it was not artistic but effective. Boyd Phelps at 2EB went to the opposite extreme and created a motor-driven key with a notched cam 18 inches across and half an inch thick, transmitting therewith the station call and the word "test." One need not feel at all guilty about such operation, or even about "laying a book on the key," *provided that* the thing is done outside broadcast reception hours, for there are not enough 5-meter men about to worry over.

Having the set operating under automatic keying one may first take the screwdriver or the metal-shell pencil (not an advt.) and go about the house testing the lighting sockets, water faucets and other metal objects for the presence of r.f. Usually it will be found. This effect should be cut down as far as possible by getting the sending set clear of all wiring, including that in the walls. When the pencil test or screwdriver test does not reveal r.f. about the house try opening the circuit of the General Radio meter and putting in a flashlamp or a little Walbert "panelite" (60 mA, 5 volts) bulb. Tune the wavemeter to the transmitter and go about hunting along wires, pipes, etc., with it. Do not be too sure that you have removed r.f. when a "hot spot" disappears; it may only have shifted.

Having finally gotten as much r.f. as possible out of the pipes, wires, metal lath, bathtub and kitchen stove we may hope that some fair part of the power is in the antenna and departing from it. At about this point it will be found that this is so, at least to the degree that the antenna transmits the stuff to nearby houses and causes hot spots to appear in them. If one of them happens to be in the family radio receiver that receiver will not work when the 5-meter set is going—or rather it will produce loud grunts and growls in place of music. For this reason it was said that these things should be checked up and the busy broadcast hours avoided. In some cases the thing is bad—in others totally absent. Be sure.

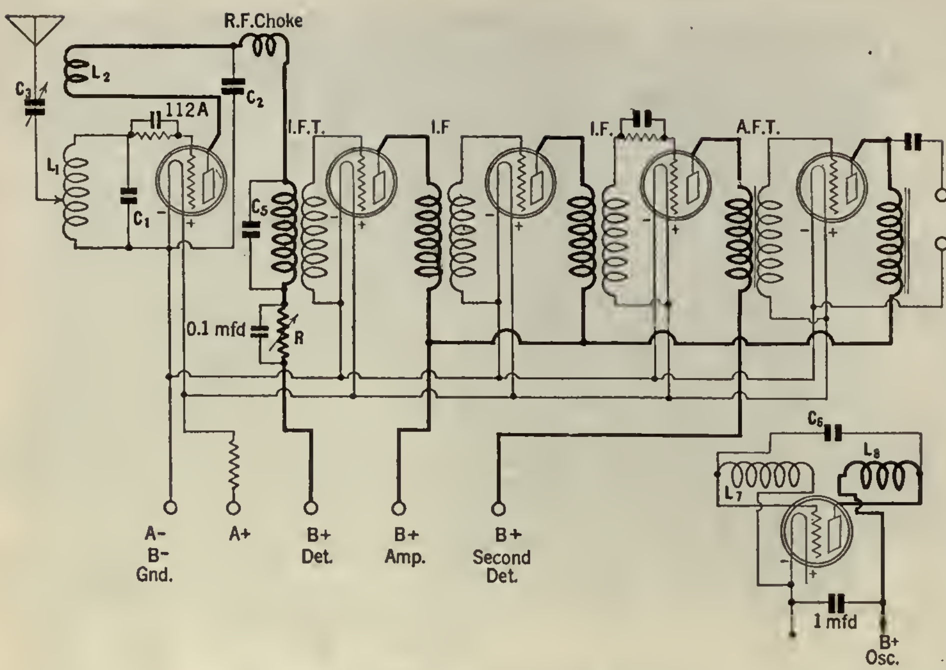


FIG. 3. A 5-METER RECEIVER CIRCUIT

This receiver, which is of the double-detection variety, is primarily a c.w. set, as explained in the text. It may be altered to a phone set by dropping off the heterodyne and adding a 5-meter heterodyne to beat with the incoming signal as in the more usual broadcast receivers. C1, C2 and C3 are trimmed vernier condensers with a maximum capacity of 15 mmfd. L1 consists of from 1 to 4 turns on a 1" diameter, depending on the rest of the circuit. C5 should not be over 0.0001 mfd., if used. Some primary turns may have to be removed from the first i.f. transformer to compensate for the effect of C5. The second and third i.f. transformers, I.F., will not need this. C6 is a 25-mmfd. variable condenser tuning oscillator coils L7 and L8, which are an i.f. transformer similar to the others. Work first without the oscillator and with a.c. plate supply at the transmitter, and then change the transmitter to d.c. and use heterodyne. The sensitivity may be improved by returning the i.f. grids to a potentiometer across the A-battery. A metal panel and baseplate are very desirable.

FARTHER AFIELD

NOW it is time to put the receiver into the family car and to go around the neighborhood exploring. Here each man may be his own guide and I will go no further than to show some of the local effects we have found around 2CSM, 2EB and 1OA.

In Figure 4 are shown some curves taken near 1OA to show that the 5-meter wave *signally* fails to act as had been predicted. It does not die off 100 yards from the station as we had been told by all authorities, but compares very nicely with normal waves. It does not, in fact, die off as fast near the station as does the 20-meter wave which we all know to be so effective at great distances.

Similar curves were run at 2EB at least 18 months ago with very similar results, but the data for these is not at the moment available to me. They are here mentioned because they brought out another very interesting point, which is to say they showed us that normal points would fall on the curve even though measured behind houses where bad screening had been expected. On the other hand points behind hills were weak, as one might expect.

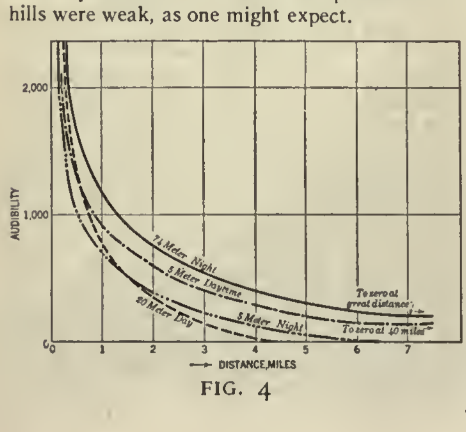


FIG. 4

When the effect of a hill in the line of transmission is investigated one finds effects such as shown in Fig. 5, which shows the effect of a certain round knob of a hill near Hartford. The shadow shape indicates the area in which the screening effect of the hill made reception weak or impossible, while the light lines are drawn in to suggest the general manner in which the wave fronts are deformed. Note the similarity to that of water ripples passing a rock.

A variety of curious effects can be observed. With a 160-meter signal one loses a great deal of intensity when the receiver is carried through a street crossed by an elevated railway structure. The 5-meter signal, on the other hand, cheerfully ignores the structure, probably because the openings in the structure are very large as compared to the wavelength.

Again, when passing under wire lines coming from the general direction of the transmitter one finds a very strong "bump" in the 160-meter signal and little or none in the 5-meter signal—which is rather difficult to explain.

Many such explorations were made in the radio flivver mentioned in the first article, likewise with various other cars. The intensities were measured and curves plotted from them. Reflector systems were tried and the general result obtained shows that the parabola does not seem to be the best reflector shape, also that the reflector wires are of best effect when not of the antenna length but a trifle longer.

DISTANCE EFFECTS

ALL of the foregoing is not spoken of to discourage attempts at long and medium distance work. On the contrary it seems that what has ailed the 5-meter game is that there has been entirely too much short-distance work and too little attempt at long distance work.

Not only must it be remembered that in turn the 200, 100, 40, 20, and 10-meter waves have defied theory and been of practical use, but in addition there has already been not a little reasonably good long distance 5-meter work. Of course we know that 20-meter work has limitations as to time and distance, and we suspect that this is even more the case with the newer 10-meter wave. Hence it is quite possible that the 5-meter wave will show its usefulness at a distance under such restricted combinations of time, weather, and distance that we may not utilize these possibilities at all and confine it to local "beam" work only. However, in view of the limited work that has been done, the few failures do not warrant dropping the wavelength.

For those that care to try it there is another possibility. Somewhat over a year ago the *Jahrbuch* described some Telefunken experiments in which various short waves were projected upward by a huge reflector that could be rolled about on the German field which acts as an equivalent for the WGY "radio-acres" at Schenectady. Some very high angles were found successful for transmission to Buenos Aires. Norvell Douglas thereupon suggested a test with the same device at 5 meters and the possibility that a slightly diffused beam shot vertically or nearly vertically upward might have a rather good chance of covering a considerable area, no matter what the exact height of the reflecting layer, if there is one that works under those circumstances at 5 meters. A reflector for the purpose is still waiting at 9EHT until we can try the thing fully, which must of necessity be delayed until early September, since Douglas is at present engaged in some ¾-meter work at General Electric's research laboratory.

WHAT IS LEFT?

WE HAVE, then, a number of interesting possibilities to back up our interesting actualities. One who has been at this 5-meter affair for quite a considerable while assures you that the working out of these possibilities is an enchanting game, made doubly so by the fact that everyone else has not done the same thing 10,000 times. Suppose then that a few of us try this Telefunken-Douglas near-vertical or wholly vertical beam while a few of the rest of us build decent double-detection receivers and listen for them. There is room also for some "straight" receivers and transmitters such as have been suggested. Certainly there are too many one-way 5-meter contacts in existence to let the two-way possibilities go on in their present state.

I am willing to help as I may, which is to say I'm perfectly willing to answer letters if their writers will but recall that stamped envelopes with a return address greatly encourage a reply!

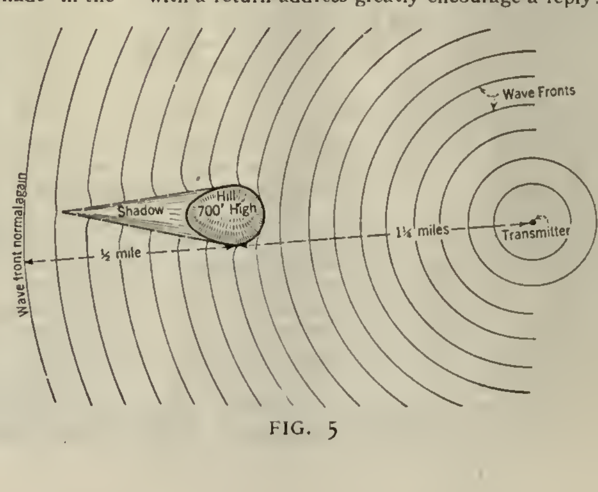


FIG. 5

AS THE BROADCASTER SEES IT

BY CARL DREHER

Broadcast Transmitters

IN THE May, 1928, issue of the *Proceedings of the Institute of Radio Engineers* Mr. I. F. Byrnes presents a paper on "Recent Developments in Low Power and Broadcasting Transmitters." Mr. Byrnes is a member of the staff of the General Electric Company, and his paper is a résumé of the recent work of the G. E. transmitter experts in this field. The latter portion is of particular interest to broadcasters.

The design requirements in modern broadcast transmitter construction are summarized by Byrnes as follows:

1. The carrier wave must be readily maintained within 500 cycles of the assigned frequency, and its frequency must not fluctuate with modulation.

2. The electro-acoustic characteristics of the equipment must be such that the output of the set is as faithful a copy as possible of the input. (The frequency transmission characteristic from microphone to antenna must be sensibly horizontal within the principal portion of the audio band.)

3. The circuits and tubes must be engineered so that the equipment will have ample overload capacity and modulation peaks will not cause distortion through "overshooting" at any point.

Illustrations of a 1 k.w. broadcast transmitter (ET-3633) are given in the paper. Normally this transmitter is built for operation on a frequency between 666 and 1200 kilocycles, although it may readily be modified for the other frequencies within the broadcast band. A condenser transmitter is supplied in the studio. The case of the condenser transmitter contains the first audio tube, which is of the UX-201A type. There follow in the audio chain one other UX-201A amplifier, a UX-210 amplifier, two UV-211 amplifiers and four UV-851 modulators. In the radio chain the tubes comprise a UV-211 as the master oscillator, two UV-211's as intermediate radio amplifiers, and one UV-851 in the output stage. A UV-211 is also supplied as an oscilloscope rectifier to indicate the percentage of modulation. The ratio of modulators to radio amplifiers (4:1) will not be a surprise to those readers who recollect the article on "Modulation" in this department for July, 1926, and the reference to Kellogg's "Design of Non-Distorting Power Amplifiers" in the May, 1925, issue of the *Journal of the A. I. E. E.* For any sort of deep modulation it is necessary to supply about as much plate power to the modulators as to the oscillators or power amplifiers in the modulation stage, and as a modulator normally takes about a quarter of the power drawn by the same type of tube delivering radio-frequency energy, the answer is obvious. In the 1 k.w. transmitter the design of which is being outlined the provision of four modulators in parallel results in a very low-impedance bank which, in combination with a good-sized speech reactor, retains the low audio frequencies and keeps the characteristic flat at the lower end.

The first three stages of audio amplification in the transmitter proper (following the UX-201A associated directly with the microphone and housed in the "bullet," as the cylindrical case of the earlier designs was called by the poets of the General Electric Company) are resistance-coupled. The condenser tube, however, delivers its output through a step-down transformer, so that the lead between the "bullet" and the set, being a connection between low impedance circuits, may be made reasonably long (a few hundred feet). The last 211 stage is reactance-coupled to the modulators. The third and fifth audio stages have volume control potentiometers on the inputs. When the input from a line is used to modulate the set the first audio tube is dropped out by means of a switch. The line, in other words, is expected to provide as much energy as the condenser mike plus two 201A tubes.

The radio-frequency chain of this transmitter starts with a master oscillator. Shielding is employed to stabilize the frequency, and the coupling of the successive radio-frequency circuits reduces harmonic radiation. There is no crystal control in this transmitter, however.

Power is supplied to the plates from a motor generator set comprising three units: the motor, excitor, and a two-commutator high-voltage generator. A separate two-unit motor generator supplies d.c. filament energy. The audio filaments are heated from a storage battery. These measures, with the addition of suitable filters, guard against noise.

The oscilloscope is similar to the oscillographs found in physical laboratories, except that it contains only one vibrator and the light source is an incandescent lamp instead of an arc. It is consequently unsuited for the taking of photographs. The operator, looking at the revolving mirror, sees a wiggling line the amplitude of which shows to what degree the carrier is being modulated. The rectified carrier supplies a reference amplitude, while the wiggling line is the audio component, likewise rectified. A loud speaker is also connected in this circuit, so that it provides both visual and audio monitoring of the radiated energy. Fig. 1 shows the connections schematically.

Sets of the ET-3633 type are in use at CYJ in Mexico City, and at Cornell and St. Lawrence Universities.

Design and Operation of Broadcasting Stations

21. WATER-COOLED VACUUM TUBES (*Part 2*)

IN GENERAL a broadcast transmitter has an efficiency of about 20 per cent. in terms of average carrier power in the antenna over power drawn from the a.c. mains. A transmitter rated at 50 kw. in the antenna, for instance, will take around 250 kw. from the power company. Most of this energy has to be carried off in the form of heat by the vacuum tube cooling system.

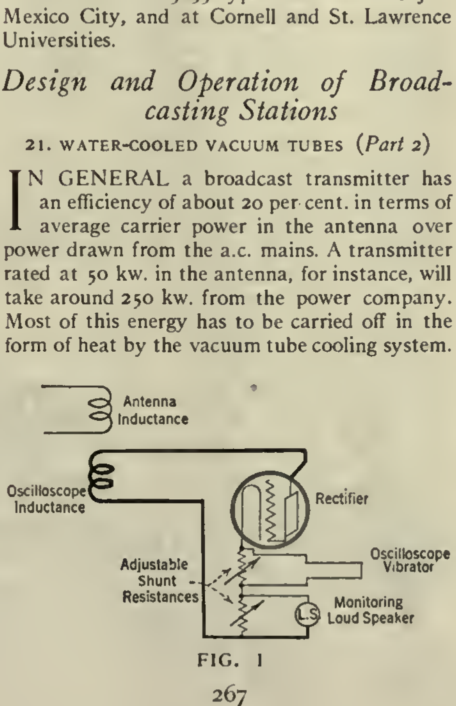


FIG. 1

The power so lost is naturally great in the case of the larger stations. The cooling systems of such installations are built to get rid of around 200 kw.—more or less of this capacity being used according to the power at which the transmitter is run. The total dissipation may be calculated in two ways, the results of which should agree. One method requires a knowledge of the total flow of water and the rise in its temperature owing to its contact with the anodes. In a specific example, let us assume a water flow of 150 gallons a minute and a rise in temperature of 5 degrees Centigrade, corresponding to 9 degrees Fahrenheit. A U. S. standard gallon weighs 8.33 pounds at 72 degrees Fahrenheit. For the accuracy of our calculation no correction need be made for another temperature. The water circulation is therefore 1249.5—let us say 1250 pounds per minute. Now, a B.T.U. (British thermal unit) is the heat required to raise the temperature of one pound of pure water one degree at 62 degrees Fahrenheit. In the case of this water system, therefore, we are carrying off, each minute, 1250 times 9, or 11,250 B.T.U. But from other relations we know that 1 kilowatt-hour equals 3415 B.T.U. One kilowatt-minute, therefore, would correspond to about 56.9 B.T.U. Dividing this figure into the value of 11,250 B.T.U. per minute secured above, we get 197.7 kilowatts as the total heat loss in the tubes. The same total should result if the individual losses of the various units are estimated electrically and added up. Roughly, the anode efficiency of an oscillator or radio frequency amplifier in a broadcast transmitter may be reckoned as 65 per cent. The anode efficiency of a modulator may be more like 30 per cent. Taking, for example, a tube with a nominal oscillator rating of 20 kilowatts, we may find it drawing a plate current of 2.0 amperes at 15,000 volts. Of this 30 kw. input to the plate only about two thirds will be converted into oscillating energy; about 10 kw. is heat loss. To this should be added the I^2R of the filament, which in the case of such a tube will correspond roughly to 1 kw. (about 50 amperes at 20 volts). The total heat loss of the tube may be taken as 11 kw., therefore. As a modulator, suppose that the tube draws a plate current of 0.5 ampere at 15,000 volts, the grid being biassed negatively about 500 volts. Of these 7.5 kilowatts, only 1.5 kw. may be transmitted as voice or tone energy, leaving 6.0 kw. as heat loss from the electrical input to the plate, to which must be added the former figure of 1 kw. for the filament, or 7.0 kw. in all. Similar calculations for the various tubes in the transmitter should result in a total equal to the loss indicated by the temperature rise of the cooling water.

The nominal rating of any vacuum tube, and the actual output which it is prudent to try to get from it, are two different things, and never more so than in the case of water-cooled tubes. It pays to underload them. This is not to say that the nominal rating is altogether a fiction. One balances output against reliability and life. A so-called 20 kw. tube, like the one the losses of which were discussed above, may deliver 20 kw. reliably enough for radio telegraph service, but in broadcasting, where extreme reliability is required, no one would think of taking more than 8–10 kw. out of it, as an oscillator or radio am-

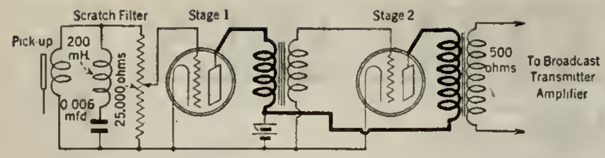


FIG. 2

plifier, or 1.0–1.5 kw. as a modulator. Even if an anode voltage of 15,000 is allowed in the instructions, it is likely to be found running at 10,000, with a plate current of less than one ampere; as a modulator it will be taking a plate current of a half or third ampere at the same lower voltage. Under those conditions it is likely to run eight or ten hours at a stretch, if the cooling suits it, without knocking out the breakers and leaving the listeners in silence, and to do this day after day. It may, in fact, do it for years; the skeletons of water-cooled tubes with 3,000–4,000 hours of useful service may be seen in museums. Some, again, are buried after 40 minutes. They all look the same when they are taken out of the crates.

The life of vacuum tubes may be prolonged if they are carefully handled. Of course, continuous water supply is a primary requisite and pressure- or flow-actuated relays are used to shut off the filament supply as soon as the water fails. When set adjustments have been changed, it is wise to resume operation at some low plate voltage corresponding to reduced power, so that undue stresses will not be set up in the tubes. Excessive vibration or rough handling of any kind should be avoided. Dropping tubes into water jackets for an inch or so, knocking off grid seals with wrenches, and similar accidents, should be as rare as announcers who shrink from publicity. Starting resistances for the filaments should be used to limit the first surge of current. The filament connections, carrying about 50 amperes, must be tight and clean, or heating at these points may cause burning and destruction of the leads. The grid and filament leads should not be so tight that any force is exerted on the walls of the tube, nor so loose that they may lie along the glass; the first condition may result in mechanical breakage; the second in puncturing following corona. Other such precautions in handling are more or less obvious. If they are not followed a water-cooled radio station can break a millionaire faster than the Street. Even if they are followed such outfits are not for the poor.

22. PHONOGRAPH PICK-UPS

ASIDE from the modulation of a broadcast station from a phonograph for program purposes, as commonly used in the smaller studios, this is about the only convenient method of running prolonged transmitter tests where music is required. Phonograph transmission by radio is, of course, nothing new. In 1917 I recollect seeing and hearing the radio telephone transmitter with which Dr. Alfred N. Goldsmith communicated from New York City with Dr. A. H. Taylor at the University of North Dakota so controlled, and probably this was not the first instance of such use of the electromagnetic pick-up. Of late years the development of the electric phonograph has made it possible to impress on a suitable radio transmitter quite decent acoustic material from wax records, a frequency range of from 100 to 4,000 cycles being covered without serious distortion. The film phonographs which, aside from their use in sound-motion picture work, are not yet commercially available, can probably do better; but this article, being of the same practical nature as the others in the series, is concerned only with reproduction from the common flat disc records.

A short bibliography of the subject, for those who wish to do a little reading in this field of electro-acoustics, is as follows:

Maxfield and Harrison: "Methods of High Quality Recording and Reproducing of Music and Speech Based on Telephone Research." *Journal of the A. I. E. E.* March, 1926.

Kellogg: "Electrical Reproduction from Phonograph Records." *Journal of the A. I. E. E.* October, 1927.

Millen: "The Electrical Phonograph." *Radio Broadcast.* May, 1927.

Millen: "Building an Electrical Phonograph." *Radio Broadcast.* June, 1927.

Wilson: "A Phonograph Amplifier." *General Radio Experimenter.* April, 1928.

Almost all the devices commonly used for transforming sound into electrical energy, such as the condenser and carbon telephone transmitters, may be used as phonograph reproducers, the actuating force being derived from the revolving record instead of from a wave in air. The most convenient commercial form has been found to be the magnetic type, which is substantially a small alternating current generator driven by the record. The operating principle is the same as that of the electromagnetic telephone transmitter, which does not happen to be common in American broadcasting. Many variations in construction are possible; Fig. 3 shows one in general use, so that it will be unnecessary for readers to take their own electric phonographs apart. The magnetic field is provided by a permanent magnet. An armature is free to move within a small amplitude in the air-gap. The movement of the needle as it is carried along the record groove causes the armature to wiggle about its pivot. The system is so designed that the motion of the armature is proportional to that of the needle. A coil of fine insulated wire surrounds the armature. The magnetic flux through this coil varies slightly as the armature vibrates. We might say that a small electromagnetic ripple is superimposed on the constant magnetic field supplied by the permanent magnet, like the commutator ripple of a d.c. generator. The result is, of course, that a corresponding e. m. f. is generated in the coil. This may be applied to the grid of a vacuum tube and amplified.

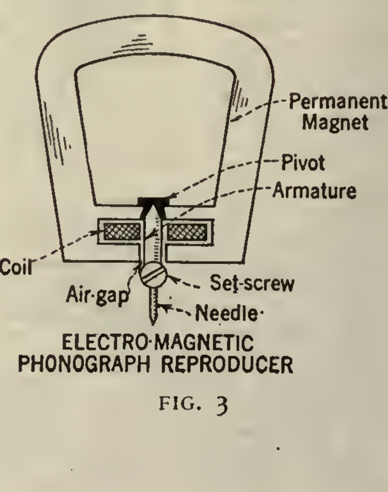
The type of reproducer thus sketchily described works with records having laterally cut grooves, as distinguished from grooves of varying depth. If suitably supported it would, of course, give some sort of reproduction with the latter style of record also. A telephone receiver with a needle soldered to the diaphragm will reproduce sound from a phonograph record, but the reproduction will not be faithful. In other words, the principle of the device is simple, but high quality output requires much finesse in design, as is shown in Kellogg's paper.

The output of magnetic phonograph reproducers varies, naturally, with the make, type of record, etc., but in general it is at such a level that two stages of amplification will bring it up to loud speaker volume. Assuming this to require a level of plus 12 TU at the speaker terminals, and calling the amplification 28 TU, we find a reproducer output of minus 16 TU. Probably a level between minus 10 and minus 20 TU will include the makes and conditions usually encountered in practice. In other words, the phonograph reproducer is good for an output level considerably greater than that of a high quality carbon transmitter, but not as high as that of a commercial telephone transmitter (zero level) in which, however, quality is sacrificed to sensitivity.

Fig. 2 shows schematically a suitable amplifier circuit. The output of the generator is such that it will not overload a tube of the 199 size, so that this may be used for the first stage, if desired. The second tube should be of the 171 or 210 size. In a broadcast station it is often considered better practice not to use smaller tubes than the 5-watt (oscillator rating) size, so that an amplifier of the 17-B type, using two 5-watt tubes, may be associated with the phonograph reproducer. In Fig. 2 the volume control is a 25,000-ohm potentiometer. These instruments are now made very cheaply and conveniently by the use of transverse wires imbedded in a carbon composition ring. A scratch filter is also shown. It happens that the noise made by the needle as it rides along the surface of the record has some of its more annoying components in the neighborhood of 4,500 cycles, so that a series circuit tuned to about this frequency will by-pass a good part of the surface noise—and also any frequencies above 4,000 cycles which may be present in the output of the reproducer. But usually it is better to sacrifice this section of the band in order to get rid of the background noise.

Inasmuch as input to the preliminary amplifier of a radio transmitter, from the wire line connecting the transmitter with the studio, is commonly at a level of about minus 10 TU, a magnetic phonograph pick-up of the type described, with a two-stage amplifier including a gain control, may readily be substituted for the line when local test modulation is desired. Likewise at the studio the same combination may be used in place of microphone pick-up, both the gain of the studio amplifier and the amplifier associated with the pick-up being kept low. With a medium gain setting the phonograph amplifier will deliver energy at a suitable level to the line, if that is desired.

Of course the 25,000-ohm volume control across the input of the phonograph amplifier is not the only type which may be used. A standard high resistance (about 400,000 ohm) interstage gain control is just as suitable. But if a line (500: 500 ohm) amplifier with such a gain control is connected to the phonograph pick-up care should be taken to omit the input transformer, so that the pick-up goes directly to the grid of the first tube. Five hundred ohms is too low for connection across a device with the impedance of most magnetic pick-ups.



ELECTRO-MAGNETIC PHONOGRAPH REPRODUCER

FIG. 3

Make Your Lighting Lines Safe For A.C. Tubes

By KASSON HOWE

The use of a fixed resistor to prevent a.c. filament overload from high line voltage is valuable when the line voltage is uniformly too high. This method does not give real regulation, inasmuch as it cannot be varied to meet irregular line voltage variations, but it does provide insurance, when the proper value of resistance is selected, against maximum line voltage overloads. It has the advantages of inexpensiveness, ease of installation, and the fact that once installed the resistor needs no further adjustment. Where the line voltage is variable, more accurate adjustment is required, and here a power rheostat may be used. This article gives the necessary data for determining line voltage variations, choosing the correct value of resistors or rheostats, and making the installation.

—The Editor.

A MAN who lives in New York City paid over five hundred dollars for an a.c. radio set. It was one of the best known makes, and he looked forward with more than a little anticipation to the pleasure and entertainment it would give him. He bought a high priced set because he wanted real tone and power, single dial control, a.c. operation, and most important of all, freedom from those minor troubles sometimes associated with radio. The set had that perfection of construction and attention to detail which gave every assurance of long and uninterrupted service.

Imagine his amazement and disappointment when two sets of a.c. tubes blew out during the first month of operation. It seemed incredible. Like many other a.c. set owners, he denounced the new type of tube as a costly failure, and criticised the manufacturer and dealer from whom he had purchased the set in no gentle terms.

To some degree he was justified, for certainly the user cannot be blamed for tube failure, no matter what the cause, unless he has actually tampered with the receiver. Probably the dealer who sold the set had to stand most of the gaff; it would, therefore, seem advisable for dealers to become familiar with the method described in this article of compensating excessive line voltage, and seriously consider the installation of such devices when the receiver is first placed in operation at the customer's home. This entails some additional expense, but will probably result in fewer calls for service and fewer dissatisfied customers. One can't, unfortunately, bring dead a.c. tubes back to life, but there are means of preventing trouble from short tube life before it ever starts. The work involved is simple, and can be done by anyone.

Consider that a.c. tubes cost anywhere from $3.00 to $6.00 apiece, depending upon the type, and it will be seen that one set of tubes blown out or with life shortened means considerable expense. And what is more to the point, it is needless expense. When an initial check on incoming line voltage shows a figure above that specified by the manufacturer as the safe maximum limit for the operation of the set, it is little short of sheer extravagance to neglect the fact and place the receiver in operation without doing something to reduce the line voltage.

An accurate a.c. voltmeter, with range from 0 to 150 volts, is the only apparatus needed to make the initial test. For practically all factory-built a.c. sets sold to-day, any figure above 115 volts should be considered excessive unless otherwise stated by the manufacturer. If the reading is above 115 on the a.c. voltmeter, it will certainly be cheap insurance for the a.c. tubes in the set to compensate excessive line voltage. A 10 per cent. increase in filament voltage may cause as much as a 50 per cent. decrease in tube life. This means, obviously, that the tube budget over the course of a year may be double what it would be if proper precautions were taken.

The extra 5-volt range from 115 to 120 volts should be regarded as dangerous and worthy of attention from the a.c. set owner. Probably a majority of a.c. sets in New York City operate at a figure somewhere within these limits. The trouble that has been experienced with short a.c. tube life is proof enough in itself that any reading of line voltage above 115 calls for attention if one wants to be absolutely safe.

Where line voltage on accurate measurement is over 120 volts there can be absolutely no question of the need for the correct value of resistor to compensate the extra voltage, which is dangerous beyond a shadow of doubt.

HOW TO GO ABOUT THE JOB

THE measurement of line voltage, as mentioned above, should be done with a high grade a.c. voltmeter. The other bit of needed information is the primary current rating of the receiver in amperes, which will in practically all cases be found upon the name plate inside the cabinet, on the power unit, or on the name plate of the power supply transformer which supplies A, B, and C voltages to the receiver. If you fail to find this after careful inspection, write to the manufacturer of the set, asking him for the primary current rating of the particular model in question.

Having the accurate line voltage figure and the current rating of the receiver, it is now an easy matter to select the correct value of resistor to reduce line voltage. Table 1 lists the current in amperes drawn by various kinds of re-

TABLE I

FIXED RESISTORS FOR LINE VOLTAGE CONTROL

Current in Amperes Drawn by Receiver	These Resistars Will Reduce the Voltage Acrass the Receiver from the Valtages Shown ta 110 Valts										
	2.5 Ohms	3.5 Ohms	5 Ohms	7 Ohms	10 Ohms	12.5 Ohms	15 Ohms	22 Ohms	31 Ohms	45 Ohms	62 Ohms
	line voltage	line voltage	line voltage	line voltage	line voltage	line voltage	line voltage	line voltage	line voltage	line voltage	line voltage
0.25						112.5	113.0	114.3	116.3	119.2	122.7
0.50				112.7	114.0	115.1	116.1	119.0	122.7	128.7	136.0
0.75			113.0	114.2	116.1	117.5	119.2	123.6	129.4	138.1	
1.00		112.7	114.0	115.6	118.2	120.2	122.2	128.2	136.0		
1.25	112.5	113.5	115.0	117.1	120.2	122.7	125.2	133.1			
1.50	113.0	114.1	116.1	118.5	122.2	125.5	128.7				
1.75	113.5	114.8	117.1	120.0	124.3	128.2	131.9				
2.00	114.0	115.6	118.2	121.5	126.5	130.8					
2.25	114.5	116.5	119.1	123.0	128.7						
2.50	115.1	117.1	120.2	124.3	130.9						

TABLE 2
CURRENT DRAINS FOR TUBE COMBINATIONS

Combination of Tubes	*Primary Current Rating (amperes)*
2, 3 or 4 226 type tubes 1 227 type tube 1 171 type tube 280 or Raytheon Rectifier	0.25
3 or 4 226 type tubes 1 227 type tube 2 171 type tubes (push-pull) 280 or Raytheon rectifier	0.45
3 or 4 226 type tubes 1 227 type tube 1 210 type tube 281 rectifier	0.50
3 or 4 226 type tubes 1 227 type tube 2 210 type tubes (push-pull) 2 281 rectifiers	0.75
2, 3 or 4 226 type tubes 1 227 type tube 1 250 type tube 2 281 rectifiers	1.00
2, 3 or 4 226 type tubes 1 227 type tube 2 250 type tubes (push-pull) 2 281 rectifiers	1.25

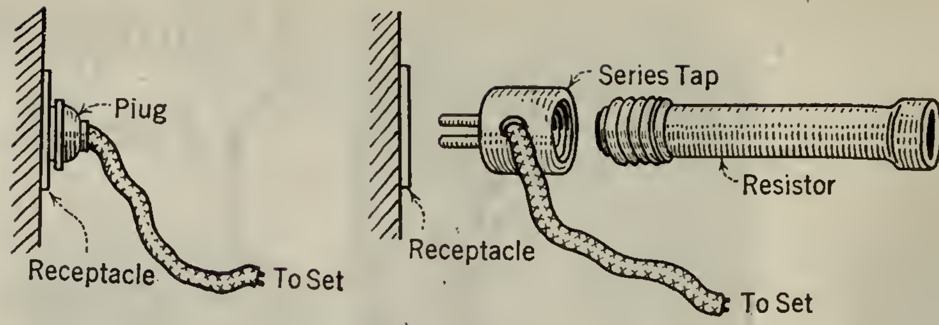


FIG. 1

At the left is an ordinary plug-in connection to an a.c. line: At the right is the method of installing a power resistor of the Edison base type in series with the receiver supply transformer, by means of a series tap. An ordinary power resistor of the correct value may be used, but does not make as neat a job as that made with an Edison base type of resistor

ceivers, a number of line voltages above 110, and the value of resistors needed to reduce excess incoming voltage to 110 volts—a safe figure for use with any commercial a.c. set.

Take the case of a receiver with a primary current rating of 0.50 amperes and a known line voltage of 119 volts. Checking on the table we find that a resistor of 22 ohms will reduce the excessive line voltage to a safe figure.

Another common current drain, usual with modern receivers using 210 or 250 type power tubes, is 1.25 amperes. Suppose the line voltage reads 120.2. Checking on the tabulation in Table 1 it is readily seen that a 10-ohm resistor will do the work of stepping the excess voltage down to 110, the safe figure.

If the set is designed for a normal line voltage of 115 volts, instead of 110, subtract five volts from the actual measured line voltage, and use the result as the line voltage in using the table.

Power resistors with Edison bases suitable for screwing into ordinary light sockets and floor receptacles are now on the market, and are particularly handy for this work. Type EB Ward-Leonard Vitrohm resistors and type 997 Aerovox Pyrohm resistors are of this type, and may be obtained in a wide range of resistances.

Having selected a resistor of the correct rating by reference to Table 1, the work of utilizing it is a matter of ten or fifteen minutes at the most. Fig. 1 at the left shows the connection to the receiver from the wall outlet before the installation of the resistor. At the right are the revised connections, using a resistor of the Edison base type. A series tap, such as the Hubbell No. 7029, provides a convenient means of mounting the resistor, and has an opening at the side for the cord running to the radio receiver.

First remove the leads from the plug. Connect the leads to the series tap. Screw the resistor into the series tap.

CURRENT DRAIN OF KIT SETS

WHERE the receiver is built at home from a kit of parts, there is no quick way of getting the primary current rating as in the case of the manufactured set. Table 2 gives the current values computed for tube combinations used in most kit sets, and will prove of value in helping to determine the correct value of resistor for use with sets built at home. The combination of tubes is indicated at the left and the primary current rating at the right.

Knowing the primary current rating of the home built set and the value of line voltage, it is an easy matter to select the correct value resistor from Table 1 and apply it as described before.

REGULATION WITH POWER RHEOSTATS

THE information given above takes care of those cases in which the line voltage is excessive but *constant*. But what about those cases in which the line voltage is sometimes normal and at other times excessive? In such instances we cannot use a fixed resistor to take up the excessive voltage, but must use a variable resistor with a maximum value of resistance equal to or somewhat more than the resistance required to reduce the line voltage to 110 volts from the maximum value of line voltage encountered during the day. For example, suppose that with the a.c. voltmeter we measure the line voltage at various times during the day and find that it reaches its highest value at 11:00 P.M., at which time it is 125 volts. We must then use a variable resistor with a maximum value that will reduce the voltage for the set to 110 volts when the line voltage is 125 volts. If the receiver draws 1.0 ampere from the line, then, from Table 1, the required resistance is 22 ohms. Companies that manufacture power rheostats that can be used are mentioned in Table 3. [There are other methods of line voltage control, but they require more elaborate and expensive apparatus. These appliances do not fall within the scope of this article, but will be treated in a later one. In "Strays from the Laboratory," on page 259, will be found some information in regard to them.—*The Editor*.]

Fig. 2 shows how to connect the rheostat to provide adjustment of incoming line voltage. First determine the primary current rating of the receiver and choose the power rheostat most nearly suited to your requirements from the data in Tables 1 and 3.

Mount the rheostat at a convenient point, away from combustible material. Break one lead of the parallel cord running from the plug to the set, and attach the rheostat in the lead as shown in Figure 2.

Finally, adjust the rheostat until the voltage across the tube filaments is the minimum satisfactory voltage for tube operation.

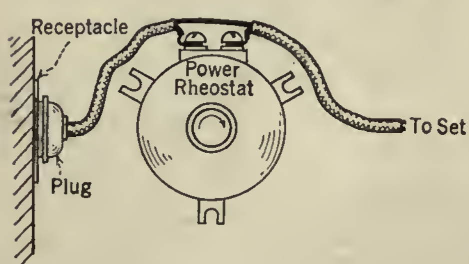


FIG. 2

The power rheostat is connected in series with the receiver power transformer by tapping one of the supply leads. The rheostat may be mounted in any convenient place, provided it is not near any combustible material, as the rheostat is required to dissipate considerable heat

TABLE 3
POWER RHEOSTATS FOR LINE VOLTAGE CONTROL

Name of Manufacturer	*Catalog Number of Rheostat*	*Remarks*
Ward-Leonard Electric Company	Vitrohm Rheostat No. 507-63 No. 507-59 No. 507-83	0–50 ohms for currents up to 0.9 amperes 0–20 ohms for currents from 1.0 to 1.75 amperes 0–12.5 ohms for currents from 2.0 to 2.5 amperes
Central Radio Laboratories	Centralab Power Rheostat	Available in suitable sizes to cover all cases.
Clarostat Manufacturing Co.	Power Clarostat	Available in three sizes: 0 to 10 ohms, 25 to 500 ohms and 200 to 100,000 ohms. The first two sizes are most useful for line voltage regulation.
Carter Radio Company	Hi-Watt Rheostat Type SW	Available in 19 different sizes from 1 ohm up to 500 ohms
Herbert H. Frost, Inc.	De Luxe Rheostat Series, 1800	Available in sizes suitable for line voltage control, from 2 ohms to 20 ohms

"Our Readers Suggest—"

A Simple Short-Wave Plug-in Coil

AN OLD tube base makes an excellent winding form for short-wave coils. A set of coils, covering the entire frequency gamut between 15 and 200 meters, is easily made, and may be plugged into the standard UX socket. Small holes are drilled into the sides of the tube base (after removing glass and cement) to permit the passage of the wires, which are soldered to the socket prongs. The wire may then be wound tightly in the conventional solenoid form or, if the tube base is grooved on a screw cutting lathe, a space wound coil may be made.

If the threading tool is ground to a blunt point twice the diameter of the wire (generally No. 26 or 28), three wires can be wound in the same slot, as suggested in Fig. 1, with only a small increase in the distributed capacity of the coil. This is the familiar single bank winding.

EVERETT FREELAND, Dowagiac, Mich.

STAFF COMMENT

A THIRD or tickler coil can be wound, tied together with thread, dropped within the tube base, and secured with a bit of wax. All terminals can be brought out to the four prongs, in accordance with the circuit of Fig. 2—a parallel feed tickler feedback arrangement. The following table gives the correct number of turns of wire for satisfactory tuning in the short-wave bands with a 0.00014-mfd. condenser:

	No. of Turns		
Wave Band	*Primary*	*Secondary*	*Tickler*
20 meters	2	4	5
40 meters	2	6	10
75 meters	4	15	15

A High-Resistance Voltmeter

A HIGH-RESISTANCE voltmeter is essential for reading voltages across the output of a power supply unit. These instruments are generally rather expensive. The experimenter can occasionally save himself some money by converting a burned out thermo-galvanometer or ammeter into a high-resistance voltmeter. It is very unusual for the coil in a thermometer, such as the Weston No. 425, to burn out. Generally, it is the thermo-couple that is fused, rendering the instrument useless as far as its original purpose is concerned.

However, by removing the burned out couple, and placing a high resistance in series with the coil, an excellent high-resistance voltmeter will be had. It is necessary, of course, to recalibrate the scale to read in the correct number of volts.

A resistance of 100,000 ohms connected in series with the coil of a Weston type 425 instrument is about correct for full scale deflection at three hundred volts.

CAPT. R. B. MORAN, Fort Monmouth, N. J.

"OUR Readers Suggest" is a clearing house for short radio articles. There are many interesting ideas germane to the science of radio transmission and reception that can be made clear in a concise exposition, and it is to these abbreviated notes that this department is dedicated. While many of these contributions are from the pens of professional writers and engineers, we particularly solicit short manuscripts from the average reader describing the various "kinks," radio short cuts, and economies that he necessarily runs across from time to time. A glance over this "Our Readers Suggest" will indicate the material that is acceptable.

Possible ways of improving commercial apparatus is of interest to all readers. The addition of an extra stage of power amplification, is a good example of this sort of article. Economy "kinks," such as the home-made power unit, are most acceptable. And the Editor will always be glad to receive material designed to interest the experimental fan.

Photographs are especially desirable and will be paid for. Material accepted will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas.

—THE EDITOR.

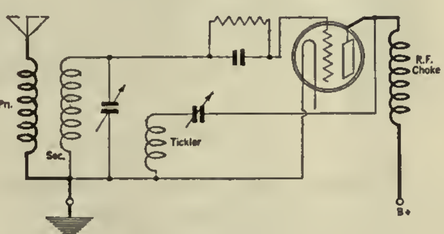


FIG. 2

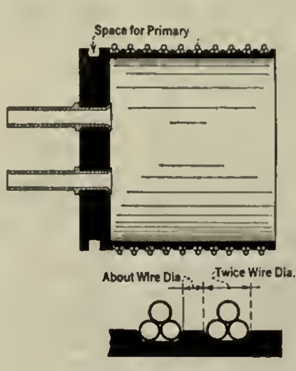


FIG. 1

Testing Filter Condensers

THE usual method of testing filter condensers by observing the size of the spark on discharge is only approximate and is often misleading. A condenser that is in poor condition and which leaks badly will usually give a spark on discharge, leading one to believe that the condenser is in good shape. Anyone having a high-resistance voltmeter may use the following method with reliable results. The condenser to be tested is charged from a d.c. source, either 90 volts of B battery or the 90-volt tap on a power unit. After waiting an arbitrary length of time—one minute, for instance—the condenser is discharged across the voltmeter terminals and the "kick" of the needle noted. It may be necessary to repeat this test, the first operation giving the approximate scale reading; then, focusing the eye on this portion of the scale, the second reading may be obtained accurately. This will allow comparison between different condensers and will show up a poor one. Where a number of condensers are to be tested a clip connection will be found convenient. Care should be taken in handling the connecting wires to prevent the charge from leaking off through the resistance of the body before it is discharged across the voltmeter. When using a 90 volt charging source and a Weston voltmeter, 0–150 volts scale, having a resistance of 13,500 ohms, it was found that high-grade condensers in good condition gave a needle swing on discharge of about 5 volts for each microfarad of rated capacity.

D. C. REDGRAVE, Norfolk, Va.

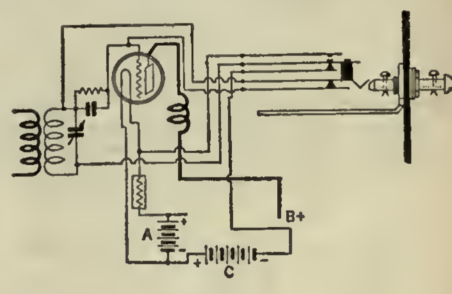


FIG. 3

A Grid-Plate Detection Switching Arrangement

RADIO BROADCAST has devoted considerable attention to the possibilities of plate or bias rectification in the detector circuit, stressing its advantages and disadvantages in comparison with the more conventional grid-condenser system. While the plate system reduces overloading on local stations, its lack of sensitivity does not recommend it for DX reception. A switching arrangement, permitting instantaneous change from one method of rectification to the other is obviously the ideal arrangement.

The writer has evolved the simple circuit shown in Fig. 3. A double circuit jack is employed to effect the change. The jack is mounted on the operating panel close to the detector tube, and functions in a push-pull fashion by means of bakelite rod ¼" in diameter, fitting the jack like a phone plug. Two small cotter pins limit the motion of the pin. (A Yaxley type VM switch may be substituted for the improvised jack idea.) The insulation on the jack should be of the best, and no paste or acid flux should be employed in making the soldered lead connections.

There is no difference in the tuning dial readings with either system of rectification. Any type of detector tube can be used, the bias battery varying between 1.5 and 6 volts, depending

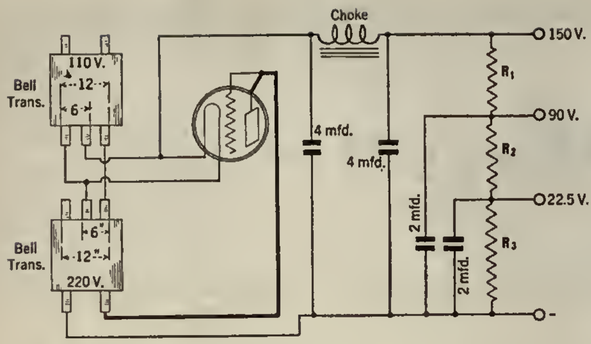


FIG. 4

upon the tube and the plate potential. These voltages should be varied until best results are obtained. Using a 201A tube, with 45 volts on the plate, a 4.5 volts C-bias will be correct.

JOSEPH A. GARDNER, Los Angeles, Cal.

A Cheap B Battery Substitute

THERE remain many receivers operated from B batteries due to the relatively high cost of power supply devices. A cheap but quite satisfactory socket power device can be built up in accordance with the diagram of Fig. 4, using two bell-ringing transformers having 6 and 12-volt secondaries.

The 6-volt winding of one transformer is used to light the filament of the rectifying tube (a 201A with the grid and plate strapped) while the 12-volt secondary is connected to the 6-volt winding of the second transformer, which will then output 220 volts from the primary, acting as a step-up transformer.

If the drain to the receiver is comparatively low, not exceeding twenty milliamperes, the primary of an audio-frequency amplifying transformer can be used as a choke coil.

The values of the condensers are indicated on the diagram. Resistors R_1 and R_2 are conveniently combined in a Duplex Clarostat, while R_3 is a fixed 5000-ohm resistor.

C. H. MEISSNER, Woodcliff, N. J.

Noisy Reception and Soldering Flux

THE soldering flux that is used in the construction of radio apparatus is generally considered a relatively inconsequential item in the building of a receiver, regardless of the fact that the use of rosin is recommended in the majority of constructional descriptions. As a service man whose endeavors are divided between the ailments of home-made and commercially built receivers, I do not think this consideration has been adequately emphasized. Too much publicity cannot be given to the detrimental effects of the average soldering flux.

Unnecessary radio noises form fifty per cent. of radio troubles, and in my own experience no less than nine out of every ten cases of noise can be traced directly to the use of an acid flux or paste. Static, poor connections, run down batteries, and antique grid leaks do not produce more than ten per cent. of the noise difficulties encountered in home-made receivers.

Nothing but rosin should be used to facilitate soldering. While the use of rosin necessitates careful scraping of joints, a very clean and hot iron, the extra trouble is more than compensated by permanently quiet reception.

Once noise has developed in a receiver an attempt, occasionally successful, can be made to clean the suspected parts, such as socket and transformer terminals and especially cracks adjacent to soldered connections. The terminals and surrounding territory should first be cleansed with an alkali, such as household ammonia. This in turn is washed away with water. A generous application of wood alcohol completes the ablutions.

This sometimes works—not always. As usual an ounce of prevention, in the way of rosin-core solder, is worth a pound of cure.

A. G. WOODWARD, New York City

A New Use for Burned Out Tubes

A BURNED out tube may be used as a neutralizing condenser in many r.f. circuits where the neutralizing capacity must be approximately the same as the grid-plate capacity of the r.f. tube. No connection is made to the filament. The difference in capacity between tube in the lighted and unlighted condition is so small as to be of no importance when used as a neutralizing capacity. A great advantage of this stunt is that no adjustment is required. Of course, the neutralizing tube will have to be of the same type as the r.f. tubes.

R. WM. TANNER,
Berkeley, Cal.

Mounting Single Hole Condensers With Special Dials

I ENCOUNTERED difficulty in mounting a single hole type of condenser with a Marco dial so that the rotor would turn without binding. This particular make of condenser would not fit the mountings that came with the dial. By adding an extra bracket to the frame, I was able to mount the condenser in a manner altogether satisfactory.

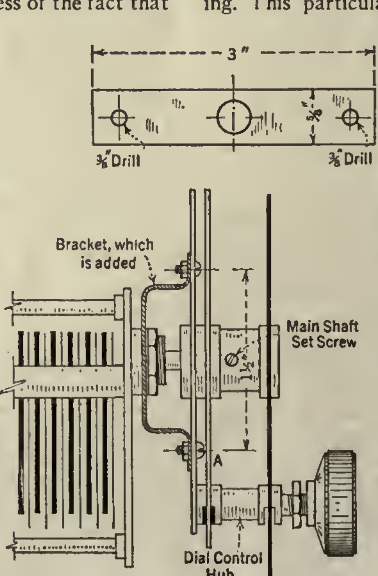


FIG. 5

This bracket is made of 1/16" brass strip 5/8" wide and 3" long. Two holes are drilled near each end with a 3/8" drill. The size of the center hole varies with the make of condenser. A 3/8' hole is drilled in the frame of the dial at *A*. A slotted hole comes drilled in the frame of the dial on the other side of the shaft.

The condenser is mounted on the bracket and the shaft inserted in the condenser hub as is made clear in Fig. 5. The bracket is then adjusted to fit and is bolted to the frame with two small bolts. The rotor is positioned so as to give the correct reading on the scale and the set screw is then tightened. The condenser is then ready for mounting on the panel of the receiver.

STUART E. MOODY, Rochester, N. Y.

Two Receivers From One Antenna

TWO radio receivers may be efficiently operated from one antenna if connected as shown at A in the diagram, Fig. 6. The size of the radio-frequency choke is not critical but it should have low distributed capacity. The one I am using is one inch in diameter wound for four inches with number 26 d. c. c. wire. Both sets must be of the non-oscillating type. Either common or separate ground connections may be used.

C. H. CAMPBELL, Bridgeport, Conn.

STAFF COMMENT

THERE are several other simple ways of operating two or more receivers from a single antenna. Different systems work better with different receiver combinations. Two additional systems are shown in B and C of Fig. 6, B being the better of the two methods.

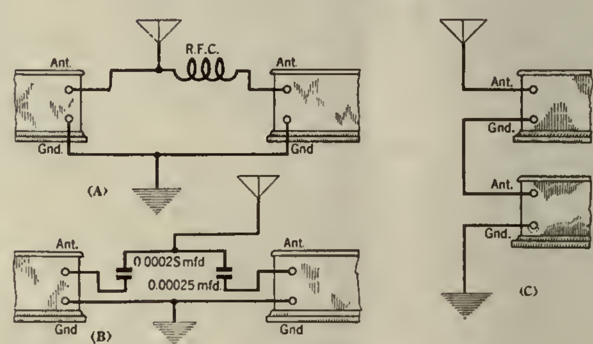


FIG. 6

An Extra Power Stage of Resistance-Coupled Amplification

AN ADDITIONAL stage of power amplification can be added to practically any receiver without touching the wiring of the set itself. A resistance-coupled power stage is assembled exterior to the receiver and is merely plugged into the output jack of the set (or wired to the output binding-posts, as the case may be). Additional connections are, of course, made to the A, B, and C batteries, while the loud speaker is plugged into the output of the power amplifier.

The power tube may be left in the receiver, or a lower power tube substituted for it, and the bias changed accordingly. The usual power tube arrangement prevails in the added stage.

ARCHIE H. KLINGBEIL, Ashtubula, O.

STAFF COMMENT

THIS additional stage of power amplification is not limited to resistance coupling, but may be employed with single transformer, impedance and push-pull circuits. In cases where the receiver is equipped with a choke coil output device, the coupling condenser and the resistor can be dispensed with, only the grid lead to the extra tube being necessary.

An external stage of amplification is not practicable on receivers already employing three steps of audio, or with sets provided with output transformers.

A Compact and Inexpensive "Trouble Shooter"

By EMIL REISMAN

THE "trouble shooter" described in this article has the virtues of simplicity in construction and operation, and low cost. It does not have the universal range of the tester described by Mr. Messenger in the July number of RADIO BROADCAST; *it is designed to measure the filament currents, plate currents and plate voltages of d.c. tubes while the set in which they are used is in operation. However, as the author points out, in most cases of receiver trouble the information given by these measurements will localize the defective parts of the circuit and make a blind search unnecessary. The compactness and portability of the "trouble shooter," together with its inexpensiveness and simplicity, should make it a very valuable instrument to the service man.*

—THE EDITOR.

SINCE the beginning of the radio art, trouble-shooting has been one of the bugbears of the engineer, experimenter, and novice. Modern broadcast receiving sets often break down when least expected, and many times at points which the designing engineer had considered invulnerable to anything short of earthquakes, lightning, or dynamite.

Most readers of this magazine have spent an evening attempting to locate the source of trouble in a balky or inoperative set. After prying out coils, transformers, condensers, and other apparatus; after testing them, and finally after several hours work, it may have been discovered that the trouble was due to a weak tube or poor connection. In itself the defect could probably have been remedied in a few minutes: but hours were spent in locating it. A tester to help in locating defective apparatus would be of great convenience.

The instrument described here is dedicated to the purpose of saving time and patience. The "trouble shooter" is used to test each tube in the set while the set is in operation. Defective apparatus connected in the tube circuits will usually change the readings of the meters in the tester. Defective tubes or improper A, B, or C voltages can also be determined. The tester will not point an "accusing finger" at any certain piece of apparatus, but will aid in localizing any trouble in the set, thus saving much time.

The tester makes use of a tube base which is inserted in the socket of that part of the set where trouble is suspected. A four-wire cable from the tube base is connected through meters to a socket in the tester. An ammeter is in series with the filament circuit, and another is connected in the plate circuit. The tube is inserted in the socket of the tester, and the set turned on. The filament and plate current drawn by the tube are indicated by the meters. The meter readings will usually give a clue as to where the trouble is located.

WHAT PARTS ARE NEEDED

A LIST of parts for the "trouble shooter" is as follows:

- A_1—1 Milliammeter, 0–10 mA (Weston model 506 or Jewell model 135), or 1 milliammeter, 0–25 mA (Weston model 506, or Jewell model 135)
- A_2—1 Milliammeter, 0–500 mA (Weston model 506 or Jewell model 135)
- R—1 10,000-ohm resistor, current carrying capacity 25 mA. (for 0–25 milliammeter) or 1 20,000-ohm resistor, current carrying capacity 10 mA (for 0–10 milliammeter)
- S_1—1 Small d.p.d.t. switch
- S_2—1 Push-pull, or toggle switch
- 2 Binding posts
- 1 UX socket
- 1 UX tube base
- 1 Panel, 8" x 3$\frac{1}{2}$", or other convenient size
- 1 Small cabinet to fit panel

The 0–10 or 0–25 milliammeter, A_1, is used to measure the plate current drawn by the tube. If it is expected to test sets using the 171 or 210 type of tubes, the 0–25 milliammeter should be used. For sets using a 112 type power tube or no power tubes the range of the 0–10 milliammeter will be sufficient. When the higher reading meter is used, a reading of one or two milliamperes will scarcely be visible on the scale; therefore if possible, use the 0–10 milliammeter. [It is a simple matter to use a low reading milliammeter, 0–10 mA, for example, and to place across it a shunt when higher currents are to be read. Such a shunt may be constructed of part of a rheostat and connected to a switch which is installed on the panel. The rheostat could be mounted inside the cabinet, of course.—THE EDITOR.]

The 10,000- or 20,000-ohm resistor, R, used with the plate current meter permits the meter to be used to measure B-battery voltage when the voltage is impressed across the two binding posts. If the 0–25 meter is used in the tester, the 10,000-ohm resistance should be used, and the reading in milliamperes multiplied by ten to give the reading in volts. The full scale voltage reading will be 250 volts. When the 0–10 milliammeter is used, the resistance should be 20,000 ohms; and the reading in mils multiplied by 20 to give volts. In this case the full scale reading will be 200 volts. Only an accurate high grade resistance should be used in order to insure correct voltage readings. Good resistors are usually guaranteed to be within five per cent. of their marked value; therefore quite accurate voltage readings may be depended on.

The principle by means of which an ammeter may be converted into a voltmeter as described in the preceding paragraph is simplicity itself. A known resistance when connected across a source of potential will allow a certain current to flow. If an ammeter is inserted in series with the resistor to measure the magnitude of the current, the voltage applied may be calculated by a simple application of Ohms law: $E = IR$. If R is made a constant value, E is directly proportional to I at all times. Therefore the voltage being measured is proportional to the deflection of the needle on the ammeter scale. Suppose a 0–10 milliammeter is to be used to measure voltages up to 200 volts. In order to determine the proper value of resistance to be used with the meter, Ohms law is again applied: $R = E/I$. Two hundred volts divided by 0.01 ampere gives us 20,000 ohms resistance. The multiplication factor is gotten by dividing the maximum voltage to be measured by the maximum reading on the meter. In this case 200 volts divided by 10 gives a factor of 20. This means that the reading in milliamperes multiplied by 20 will give the voltage.

CONSTRUCTION OF THE TESTER

THE tube base is taken off a discarded tube, and should be of the UX type. Break away as much of the glass as possible, and then scrape out the cement. When the base is thoroughly cleaned out, solder a flexible lead about two feet long to each of the contact pins inside the base. It is advisable to use leads of a different color for each of the four wires to prevent confusion when the unit is completed. The handle for the tube base may be made from a piece of broom stick. Saw a piece about three inches long from the top of the broom—making sure, of course, that your wife is not in the vicinity. Bore a hole lengthwise through the center large enough to accommodate the four flexible leads which you have soldered to the base. Now, whittle down the end of the handle until it fits snugly within the base. Pass the four leads through the hole; coat the end of the handle with glue, and force it into the base. The four leads should be tied or taped together in several places in order to make one compact cable. The free end of the cable connects to the

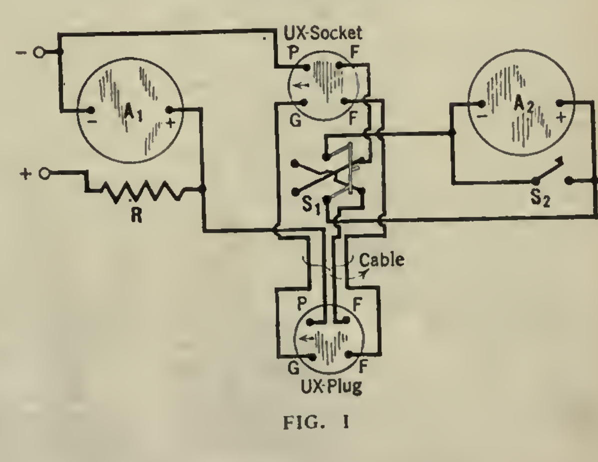


FIG. 1

NORMAL PLATE AND FILAMENT CURRENT FOR VARIOUS TUBES

Type	Filament Current (mA)	Plate Current (mA)						Grid volts					
		45 V.	67 V.	90 V.	135 V.	157 V.	180 V.	45 V.	67 V.	90 V.	135 V.	157 V.	180 V.
200A	250	1.0											
201A	250		1.7	2.0	2.5				-3.0	-4.5	-9.0		
112	500			4.0	5.8	7.9				-4.5	-9.0	-10.5	
112A	250			Same as 112						Same as 112			
171	500			11.0	16.0	18.0	20.0			-16.5	-27.0	-33.0	-40.5
171A	250			Same as 171						Same as 171			
199	60	1.0	1.7	2.5				-1.5	-3.0	-4.5			
120	125			3.2	7.0					-16.5	-22.5		
12	250		1.8	2.6					-3.0	-4.5			
226	1050 a.c.			3.7	6.0		3.8			-6.0	-9.0		-16.5
227	1750 a.c.			3.0	5.0		6.0			-6.0	-9.0		-13.5
					250 V.	350 V.	425 V.				250 V.	350 V.	425 V.
210	1250				12.0	16.0	18.5				-18.0	-27.0	-35.0

The operating currents and voltages of the standard tubes are given in the table above as helpful data for use with the trouble shooter. The table may be clipped and pasted on one of the panels of the instrument, thus making it handy for use in checking up on tubes.

tester through a hole in the back of the cabinet.

A d.p.d.t. switch, S_1, is used to reverse, when necessary, the direction of current flow through the filament milliammeter, A_2. The filaments of various sets are not always wired alike as to polarity; hence, when some sets are tested you will find it necessary to have the switch to the right in order to have the filament meter read; with other sets the switch will have to be thrown to the left.

A small short-circuiting switch, S_2, is connected across the filament milliammeter, A_2, for protective purposes. The meter should be short-circuited when tubes with a filament consumption of more than 500 milliamperes, or tubes using A. C. on the filament, are tested.

The placement of the parts is shown in the photograph, and Fig. 1 gives the wiring of the instrument, which is quite simple.

TROUBLE SHOOTING

TO TEST a set thoroughly with the "trouble shooter," take out the first radio-frequency tube and insert in its place the tube base of the tester. Place the tube in the tester socket, turn the set on, and note the readings of filament and plate current. If possible, adjust the filament current to its normal value. If the plate current is not near normal, replace the tube with one which is known to be good, and again note the plate current reading. If the reading is the same as the previous one, the defect probably lies in that part of the set which is connected to the tube circuit; or perhaps the B or C battery voltage is not of the proper value. Each tube socket in turn should be tested until the trouble is localized. It should not take more than a few minutes to test the entire set.

Below is given a list of symptoms and a guide to where the trouble can probably be found. After becoming accustomed to using the tester you will find that with very little trouble you can completely analyze a set.

1. *Filament current—no reading*
   - (a) filament circuit open
   - (b) defective rheostat or ballast resistance
   - (c) A-battery dead
   - (d) defective tube
2. *Filament current—below normal*
   - (a) too much rheostat resistance in the circuit
   - (b) poor contacts in filament circuit
   - (c) A-battery voltage low
3. *Filament current—above normal*
   - (a) insufficient rheostat resistance in the circuit
   - (b) A-battery voltage high
4. *Plate current—no reading*
   - (a) plate circuit open
   - (b) transformer primary open
   - (c) B-battery dead
   - (d) B-battery polarity reversed
   - (e) defective tube
5. *Plate current—below normal*
   - (a) C-battery voltage high
   - (b) B-battery voltage low
   - (c) tube defective or needs reactivation
6. *Plate current—above normal*
   - (a) grid circuit open
   - (b) transformer secondary open
   - (c) C-battery voltage low
   - (d) C-battery polarity reversed
   - (e) B-battery voltage high
   - (f) defective tube

The table on this page, giving the normal plate and filament currents and grid biases, for the standard vacuum tubes, will also prove helpful in trouble-shooting.

When testing B-batteries, be sure that the tester is not connected to the set. The terminals of the B-battery are connected to the proper binding posts, and the milliampere reading noted. The reading multiplied by the factor gives the voltage. It is wise to scratch the multiplication factor on the panel. Also mark the positive binding post, so that the battery may be connected with the correct polarity each time.

The "trouble shooter" is not guaranteed to be a cure-all, but when used intelligently it will save the user much time, trouble, and possibly expense. For the laboratory, and for service and repair men, this instrument will be found invaluable.

Book Review

WHAT USE BROADCASTING? By William G. Shepherd, included in "Mirrors of the Year." Frederick A. Stokes Co., New York, 1928. Price $4.00

IT IS fitting that the current "Mirrors of the Year," among articles on aviation, the state of the nation, Messrs. Sacco and Vanzetti, feminism (U. S.), the fevers of journalism, the progress of science, art, literature and the movies in the United States, should include a treatise on broadcasting. Mr. Shepherd's discussion is reprinted from *Collier's*. It is not a depressingly serious effort, and will be remembered no longer than the paper on the theatre which precedes it or the article on the girls' clothes which follows, but it fits neatly into the jazzy although quite informative pages of the Messrs. Frederick A. Stokes Company's compendium.

Mr. Shepherd's principal interest is in the political and sociological aspects of broadcasting, and he begins with a story about the Republican Convention at Cleveland, in June, 1924. He says he saw there a "puzzled looking young man fooling around with various gadgets," in a glass booth. The young man turned out to be Graham McNamee, then just beginning his career as perhaps the premier political reporter of the air, although already famous as a radio announcer in other fields. Mr. Shepherd may be romancing a little, because I do not believe that anybody ever saw McNamee puzzled, and the operators would kill him if he touched the gadgets—unless, of course, he first gave them a drink or other good and valuable consideration.

Mr. Shepherd goes on to tell how, in contrast to the unknown functions and future of broadcasting in 1924 politics, in 1927 President Coolidge waited ten minutes before starting his speech at a United Press banquet, because the stations of the broadcast chain were not ready to go on when he was. In a considerable number of years of active broadcasting I never saw that happen, but probably the President would wait in such a contingency, because he knows that the audience along the network far exceeds that visibly present. The same thought, no doubt, emboldens the broadcast technicians to erect a rampart of microphones before the Executive so high and wide that most of the people in the hall where he is speaking can't see his face.

"What Use Broadcasting" continues with some consideration of the delicate problem of free speech on the air. "There is more freedom of the air in 1928," says Mr. Shepherd, "than there was early in the broadcasting era." This is true, and I believe, as apparently Mr. Shepherd does, that it is due to the influence of a highly intelligent and tolerant conservative, Mr. M. H. Aylesworth. I am myself in the liberal and sometimes in the radical camp, and so I may be allowed to say without suspicion of bias that, in situations where amicable adjustment is possible, I would far rather deal with a sincere and fair-minded Tory than with the average jumpy and querulous liberal. For an illustration on a large scale, just look at Dwight Morrow and Mexico. In broadcasting, Mr. Shepherd cites the case of Mr. Norman Thomas speaking over WJZ without any censorship, and without pulling down the pillars of society. Since then, as a matter of fact, not only a few socialists, but even several communists, have agitated the 50-kilowatt transmitters, and what happened was precisely what my kind customers may recollect I have been predicting in our "As the Broadcaster Sees It" department for the last three years—nothing. The listeners were all tuned to the other channel, enjoying a jazz band. Of course the defenders of the downtrodden do not get a fifty-fifty break on the air, or anything like it. They have no more chance of that than Mr. Hughes would have of presenting the capitalist case in Russia. But in this country they are certainly getting a better break in broadcasting than in the domestic movies, for example. Can you imagine one of the news reels portraying the handsome countenances of Messrs. Foster and Gitlow, even once? The present regime of intelligent and unfrightened conservatism in the high seats of broadcasting is about all that can be expected while the stone angel on top of the Cathedral of Saint John the Divine stands mute with his trumpet raised to his lips, not yet ready to announce the Resurrection.

—CARL DREHER.

An Adapter for *Long-Wave* Reception

By W. H. WENSTROM

Lieut., Signal Corps, U. S. A.

ROCKY POINT

MANY listeners are turning away from the narrow confines of the broadcast band, in which too often musical excellence and technical perfection are stifled under the never-ending flood of politics and sectionalism. Naturally enough, the recent trend has been toward the short waves. It would be useless to claim that there are more interesting things above the broadcast band than below it, but much of the real pleasure of radio lies in a broad interest rather than a narrow one, in standing aloof from the fads, in being somewhat original. And an exploration of the waves between 550 and 2500 meters will not prove entirely what Carl Dreher calls "chocolate-and-pineapple" originality.

In the July issue of RADIO BROADCAST a short-wave adapter for the R. B. Lab. receiver was described. This article continues the completion of the Lab. receiver, but the adapter here described may be used with practically any set having one or more stages of audio-frequency amplification. As the adapter contains a detector circuit, only the audio circuits of the receiver are used. The adapter's phone broadcast reception possibilities, in America at least, are slight. Most of the signals within its range are in code. But the adapter makes a good code practice set for those who wish to broaden their radio knowledge in this direction.

THE long-wave adapter described here was designed in conjunction with the short-wave adapter described in the July number of RADIO BROADCAST, *to extend the receiving range of the R. B. Lab receiver, so as to include all the wave-bands between 20 and 2500 meters. However, the unit may be used with any receiver that embodies one or more stages of audio. By substituting a 0.0005-mfd. tuning condenser for the 0.00035-mfd. condenser illustrated the tuning range may be extended so as to receive NAA, at 2677 meters, and other stations above 2500 meters. Also a plain dial may be substituted for the more expensive vernier dial mentioned in the list of parts, since long-wave stations will remain tuned-in over several dial degrees.*

—THE EDITOR.

GENERAL DESIGN

The adapter, whose circuit is shown in Fig. 1, consists essentially of a tuned detector circuit which can be made to regenerate or oscillate. For economy and compactness the regeneration condenser is quite small. The antenna coupling is inductive and variable. The detector output terminates in a tube base which plugs into the detector socket of a standard broadcast set. The adapter detector (with its high tuning range) in this way temporarily replaces the set detector. Two Silver-Marshall plug-in coils L_1, L_2, and L_3—the 111-D and the 111-E—are used. With the 0.00035-mfd. tuning condenser, C_1, the respective tuning ranges of these coils are 600-1400 meters and 1100-2500 meters. The calibration chart in Fig. 2 will probably hold quite approximately for any adapter, as on long waves circuit changes do not have a very great effect. A 0.0005-mfd. tuning condenser would extend the tuning ranges slightly, and would be desirable for those who wish to copy the NAA time, weather, and press broadcasts on 2677 meters.

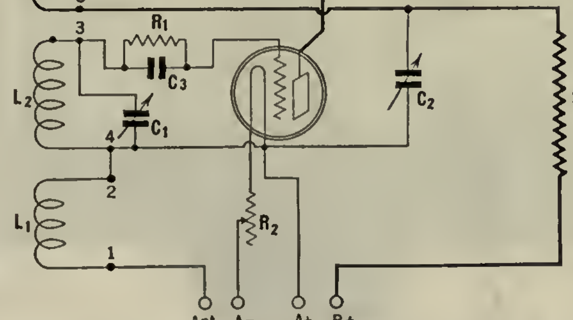


FIG. 1. THE CIRCUIT DIAGRAM

For effective reception at higher wavelengths the antenna should be rather long. It is true that many stations can be heard on the usual 100-foot broadcast antenna, but signals are louder with a longer one. The writer used a 250-foot single wire in tests, and 750 to 1000 feet would not be too long. Even on short waves a long, low single wire seems to improve the signal-noise ratio upon which satisfactory reception depends. Where the lighting wires are overhead rather than underground, a light socket antenna plug offers possibilities.

CONSTRUCTIONAL DETAILS

THE construction is plainly apparent from the diagrams and photographs. The unit is so simple that none should have trouble with it. The arrangement of parts and wiring can, of course, be varied to suit individual requirements. The wiring is done with solid Acme Celatsite. As explained in the short-wave adapter article, the a.c. tube is not a good oscillating detector. For this reason a d.c. tube is always used in the adapter; it may be almost anything from a UX-112A to a UX-199. The UX-112A, UX-200A and Ceco H are more sensitive than others. If a UX-199 is used with a 6-volt battery the rheostat, R_2, should be 50 ohms.

The plug connections are clearly shown in Fig. 4. If the receiver power is direct current, the adapter requires no additional battery. If the receiver power is alternating current, the adapter requires an A-battery. For intermittent use with a storage battery tube four or eight dry cells should do; a UX-199 tube will run even on a 4½-volt C-battery. A list of the parts used in this particular set is given below.

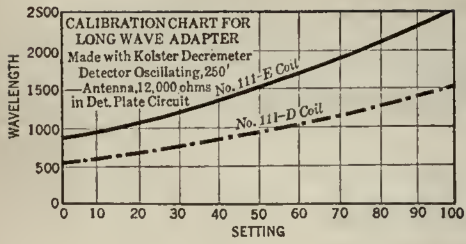


FIG. 2

THE PARTS USED

HOME constructed coils for this adapter can be made in this manner: For a coil with a wavelength range corresponding to curve 111-D, Fig. 2, wind on a 2″ cylinder a bank wound coil consisting of 13 piles of 20 turns each for the secondary. The winding at one end of the coil, L_1, should contain 100 turns and the rotor winding, L_3, should contain about 60 turns. For a coil to tune as indicated by curve 111-E wind 9 piles of 44 turns each on a 2″ form, the other two windings being the same as above. Use about No. 28 s.s.c. wire for all the windings.

The other parts specified for this adapter have no special electrical characteristics and parts electrically equivalent to those mentioned in the list may, of course, be used.

C_1—Hammarlund type M L-17 variable condenser, 0.00035 mfd. (A 0.0005-mfd. variable condenser may be used, as explained in the text)
C_2—Hammarlund variable condenser, 0.0001 mfd.
C_3—Sangamo fixed condenser, 0.00025 mfd., with grid leak clips.
L_1, L_2, L_3—Silver-Marshall coils, No. 111-D and No. 111-E
R_1—Tobe Tipon grid leak, 6 megohms
R_2—Yaxley switching rheostat, 30 ohms (50 ohms for UX-199 tube)
R_3—Durham resistor, 10,000 ohms
1 Karas 4″ vernier dial
1 Benjamin cushion UX socket
1 Silver-Marshall coil socket, type 515
4 Eby binding posts, small
1 Bakelite panel, $\frac{3}{16}$″ x 7″ x 9″
1 Bakelite binding post strip, $\frac{3}{16}$″ x $\frac{3}{4}$″ x $4\frac{3}{4}$″
1 Plywood baseboard, 1″ x 8″ x $8\frac{1}{2}$″
Celatsite wire

WHAT THERE IS

THERE are plenty of signals above the broadcast band. Some valuable information is contained in the chart on page 169 of the July issue of RADIO BROADCAST, and in the table on page 52 of the May issue. All these frequencies are assigned by international conferences in which every important nation is represented. Six hundred meters is the calling wave for ships of all nations on the seven seas. When contact has been established with another ship or the shore, messages are usually handled between 600 and 1000 meters, though the 600-meter wave may be used for messages where calling is not interfered with. This wave is also used for marine distress calls, which are fortunately rare. When the broadcasting stations shut down for an SOS, one can often hear spark signals from the disabled ship itself.

Marine direction finding occupies 800 meters. A ship in doubt of its position calls a control station on shore. Then two or more widely separated stations on shore take radio bearings on the ship's transmitter. When these bearings are plotted on a chart their intersection gives the ship's position, which is promptly radioed to it by the control station on shore.

When the coastal weather is at all foggy one can hear the radio beacons sending out their distinctive signals. They are small tube transmitters, usually aboard lightships, and their note is c.w. modulated at about 1000 cycles. Their signals may be found on the Department of Commerce navigation charts. A few in the New York area actually checked by the writer are: Nantucket Shoals Lightship—4 dashes; Fire Island—2 dashes; Ambrose Channel—single dashes; Seagirt Lighthouse—3 dashes. By listening to these beacons start up, one after another, it is possible to trace roughly the progress of thick weather along the coast. People who live far inland will miss a great deal of this marine radio, unless they are near the Great Lakes.

Long-wave broadcasting has never taken hold in America, but it is important in Europe. Theoretically, the range of a 1400-meter station should be over three times that of a 400 meter station of the same power, but for some reason the long-wave European broadcasters do not seem to get out very well. Perhaps the average receiving antenna is too small for effective long-wave work. Some long-wave European broadcasters using over 10 kw. are: LP, Berlin, 1300 meters, 12 kw.; projected station at Moratala, Sweden, 1304 meters, 40 kw.; projected station at Moscow, 1450 meters, 40 kw.; 5XX, Daventry, England, 1600 meters, 16 kw. (from *Citizens Radio Call Book*). Trying for these stations should prove interesting during the winter months.

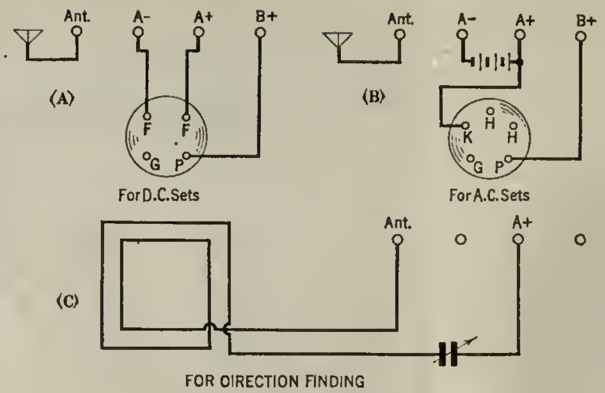


FIG. 4

Large ships use bands between 2000 and 3000 meters for through traffic, and often attain surprising ranges. Two or three years ago the transport *Chateau Thierry* worked New York with its 5-kw. arc from a position near San Francisco.

Some applications of this long-wave adapter make it useful on small yachts or other ships equipped only with conventional broadcast receivers. By listening on 600 meters in fog or storm, the navigator can get some idea of the number of ships near him, as well as bits of information about the weather and sea from the messages these ships exchange. The Navy weather and press broadcasts may also come in very handy at times. By listening to the radio beacons on 1000 meters the yachtsman can get a rough idea of his distance from them. It would even be possible to rig up a loop on deck—say about 30 turns on a frame two feet square, connected in series with a large variable condenser and the adapter primary Fig. 4 shows the connections. Signal changes are noted on rotating the loop; the minimum signal means that the beacon is in a direction perpendicular to the plane of the loop. This arrangement should work up to five or ten miles.

Though these higher waves are almost unknown to most radio listeners, they play a great and increasing part in the business of the world. The man who is bored with broadcast reception, who wishes to broaden his interest and extend his knowledge, will find a new field in exploring the possibilities of the radio spectrum. above the broadcast bands.

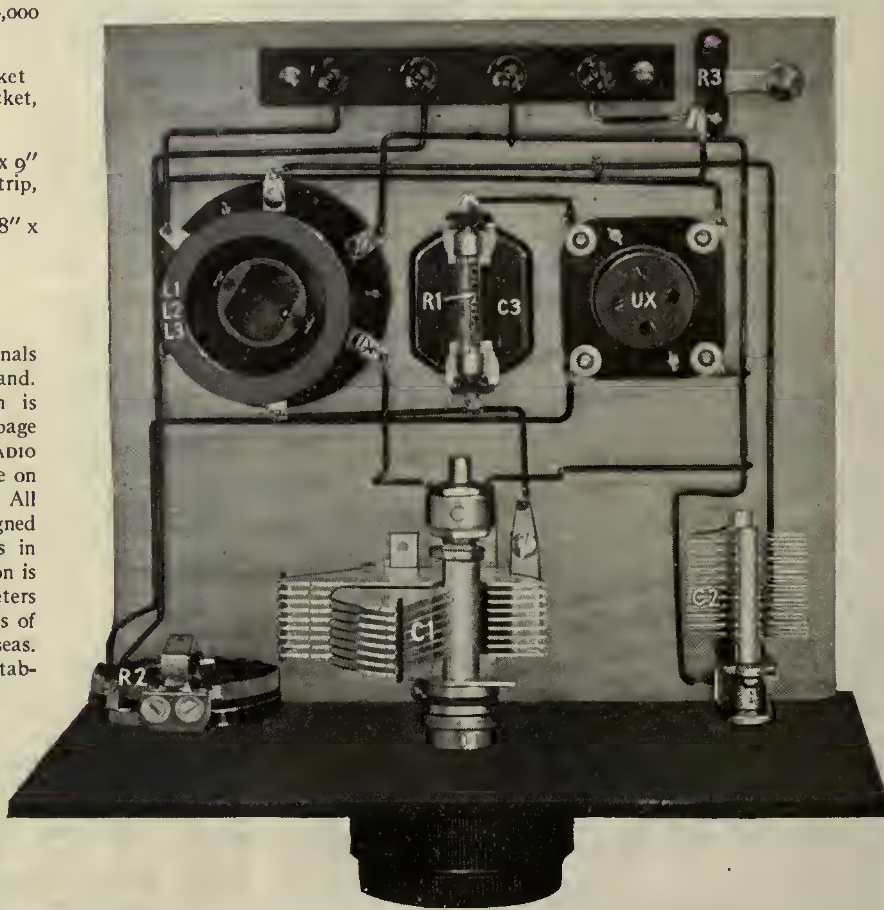


FIG. 3. THE PLACEMENT OF THE INSTRUMENTS

No. 7. September, 1928.

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

Stromberg-Carlson Receivers Nos. 635 and 636

THE Stromberg-Carlson receivers Nos. 635 and 636 are self-contained, completely light-socket-operated radio receivers, the receiving apparatus and the complete power supply being mounted on one metal base and contained in a single cabinet. The No. 635 receiver is housed in a table mounting cabinet; No. 636 is a console model. The same apparatus and circuit is employed in both. Type 227 tubes are used throughout the receiver with the exception of the audio output tube, which is a type 171 tube, and the rectifier which is a full-wave type 280. The tuning system uses four stages, consisting of the tuned antenna stage followed by three stages of tuned and neutralized radio-frequency amplification. The coils are enclosed in aluminum shields and the variable condensers are all ganged to the single tuning control. The detector is the C-battery type, and the audio amplifier is a two-stage transformer coupled affair. The volume control consists of two variable resistors mounted on the same shaft and operated from a common control, one of the resistors controlling the amount of signal energy entering the r.f. amplifier and the other controlling the amount of energy admitted to the detector.

MODEL 635

The Nos. 635-A and 636-A receivers are designed to operate efficiently on 105-125 volts, 50-60 cycle a.c.; the Nos. 635-B and 636-B receivers on 105-125 volts, 25-40 cycle a.c.; and the Nos. 635-C and 636-C receivers on 210-250 volts, 40-60 cycle a.c.

The receiver is equipped with a switch to compensate low and high line voltages. With voltages lower than those recommended for efficient operation of the receiver, the receiver may operate satisfactorily, but the amplification will be decreased and the tone quality impaired; and with voltages greater than those recommended, the life of the tubes will be somewhat shortened.

TECHNICAL DISCUSSION

1. The Tuning System.

The antenna stage of the receiver is tuned, which makes the set more sensitive than receivers of the same type employing an untuned antenna system. One control operates all of the tuning condensers, C, simultaneously, accurate electrical alignment of the various stages being obtained by the use of small midget condensers, C_1, in each stage connecting across the main tuning condensers; these latter condensers are adjusted at the factory.

2. Detector and Audio System.

Plate rectification or "grid bias" method of detection is used, followed by two stages of high-quality transformer coupled audio amplification, the ratio of the first transformer being 4:1, and that of the second being 2.8:1. The secondary of each audio transformer is shunted with a 1.0 megohm resistor to obtain the desirable audio-frequency characteristic. The output of the audio system is coupled to the loud speaker by means of a 60-henry choke and a 2.0-mfd. condenser A correctly designed "high-frequency cut-off" audio filter is included in the audio output system. A phonograph pick-up jack is provided in the front panel of the receiver, which, upon insertion of the phonograph pick-up plug, connects the output of the pick-up to the audio system in place of the detector output of the receiver.

3. Volume Control.

The volume control consists of two separate units operated simultaneously by the same control knob. The primary of the antenna coil has a 10,000-ohm potentiometer, R_1, shunted across it, with the variable contact grounded. This controls the amount of signal admitted to the radio-frequency amplifiers. The second unit is a 10,000-ohm variable resistor, R_2, shunted across the primary of the third radio-frequency transformer. This controls the amount of signal admitted to the detector.

4. Filament Circuits.

The heaters of the three radio-frequency and first audio tubes are connected in parallel, but with separate twisted pair connections to each tube from the power transformer secondary, which supplies approximately 2.3 volts to each of these tubes. The power transformer secondary which supplies these tubes is provided with a grounded center tap for hum balance. A separate secondary of the power transformer supplies approximately 2.3 volts to the detector tube heater; this results in a better condition for suppressing hum. A 10-ohm potentiometer, R_3, with its variable contact grounded for hum balance, is shunted across the current supply to this tube. The filaments of the audio output tube and the dial light are connected in parallel and are supplied with approximately 4.5 volts from the power transformer. A 20-ohm potentiometer, R_4, with its variable contact grounded for hum balance, is shunted across this current supply.

5. Plate Circuits.

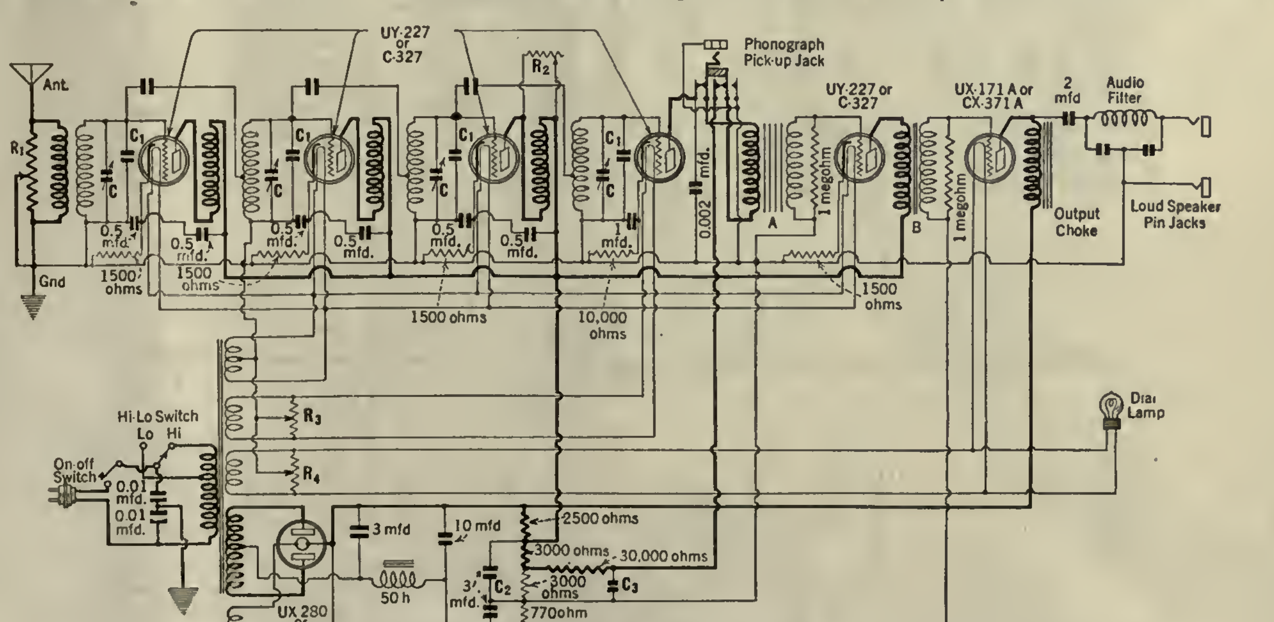
The plates of the radio-frequency and first audio tubes are supplied with approximately 110 volts d.c. from the power equipment. The detector plate is supplied with approximately 36 volts d. c. and the audio output tube is supplied with approximately 180 volts d. c. from the power equipment. The radio-frequency and first audio plate supply is "bypassed" to ground by a 3-mfd. condenser, C_2, which is contained in the power equipment, and the plate supply to the radio-frequency tubes is "by-passed" to the cathode at each radio-frequency tube by a 0.5-mfd. capacitor. The detector plate supply is "bypassed" to ground by a 3-mfd. capacitor, C_3, which is contained in the power equipment.

6. Grid Circuits

The grids of the radio-frequency and first audio tubes are biased negatively approximately 5 volts with respect to the cathodes, by means of a 1500-ohm resistor connected between each cathode and ground. The detector grid is biased negatively approximately 3.5 volts with respect to the cathode, by means of a 10,000-ohm resistor connected between the cathode and ground. These biasing resistors are "bypassed" by 0.5-mfd. capacitors in the radio-frequency stages, and by a 1-mfd. capacitor in the detector stage. This prevents the resistors from having any effect on the radio frequency current and insures stability. The power equipment supplies approximately 40.5 volts negative bias to the grid of the audio output tube.

7. The Power Supply

The power transformer consists of a primary winding and secondary windings which supply the radio-frequency and first audio tube heaters, the detector tube heater, the audio output tube and dial light filaments, the rectifier tube filament, and the high voltage which is rectified and filtered to supply the plate voltage for the receiving tubes. The grid bias voltage for the audio output tube is also supplied from this source. The primary circuit of the power transformer is provided with a "Hi-Lo" switch, which compensates for high or low line voltages. Full-wave rectification is accomplished by one UX-280 Radiotron or CX-380 Cunningham rectifier tube, and the filter system consists of a 50-henry choke, a 3-mfd. condenser and a 10-mfd. condenser. A voltage divider connected across the output of the rectifier and filter system supplies the correct voltages to the radio-frequency, detector, and audio tube plates and to the grid of the audio output tube.



THE RECEIVER CIRCUIT

No. 8. **September, 1928.**

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

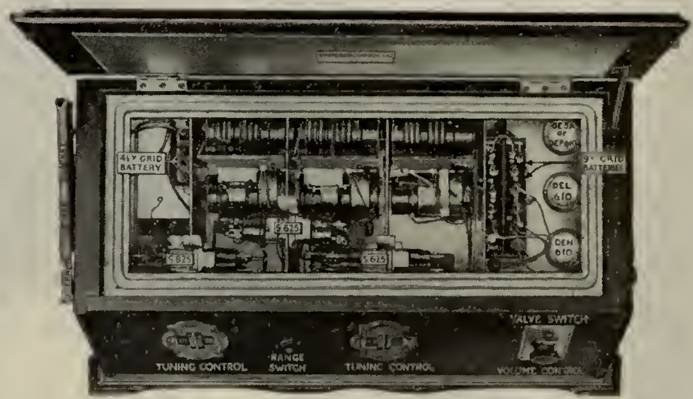
The Marconiphone Model 61 Receiver

THIS Service Data Sheet is devoted to a description of one of the leading receivers now being manufactured and sold in England. The design of this receiver affords some interesting comparisons with American receivers of similar design, which should prove interesting to many of our readers. Screen-grid tubes were available and in use in England for several years before the advent of the type 222 tubes in America, and the double-ended construction adapted by our British friends has some advantages in simplifying receiver design, which are pointed out below.

THE most interesting receiver in the British radio field at the present moment is undoubtedly the Marconiphone Model 61. This six-tube set has three screen-grid tubes, a C-battery type detector and two resistance-capacity-coupled audio-frequency stages. The latter are normal in construction, but the radio-frequency end of the instrument is decidedly unique and gives many valuable lessons to the experimenter.

The tubes employed are of the double ended type due to Captain Round, the famous Marconi engineer. Their construction is shown in the photographs below. It will be seen that a "V" filament and standard grid are mounted on one glass foot, and the plate with the screen grid on a second, the electrodes then being assembled in a glass bulb and the tube finished off with two caps.

The anode and screening grid are flat, the latter having a "skirt" approximately $\frac{1}{4}''$ wide brought as closely as possible to the glass to prevent edge effects. The great practical advantage of this construction is shown in the top view of the receiver, where it will be seen that the tubes are mounted horizontally with their screening grids in the planes of the inter-stage partitions, which are cut away just sufficiently to allow for the diameter of the glass. The whole of each stage is entirely enclosed by the screening when the cover is closed. Furthermore, by an ingenious process the magnesium "getter" used to remove the last traces of gas from the tube is limited to the plate end of the bulb and cannot therefore form a conducting path past the screening grid.



THE GENERAL LAYOUT OF PARTS

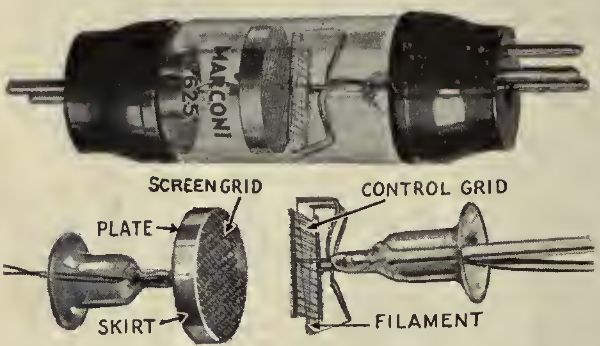
A 6-volt, 0.25-ampere filament is used, and at the standard operating voltages of 120 on the plate, 80 on the screening grid and minus $1\frac{1}{2}$ on the control grid, the amplification factor is 110 and the plate impedance 175,000 ohms.

Full advantage of this high mu value cannot be taken when three stages are in use, as instability is inevitable. A step-up of 30-35 per stage is actually achieved in Model 61. Incoming signals are therefore amplified 30,000 times before reaching the detector. Multiply this by a conservative 25 as being the step-up of the detector and two audio-frequency tubes and we theoretically obtain a total magnification of nearly three quarters of a million times between aerial and output! With this stupendous increase it is clearly essential not only to adopt the most perfect screening but also to take precautions against coupling through the common wiring and batteries, in order to obtain stable operation.

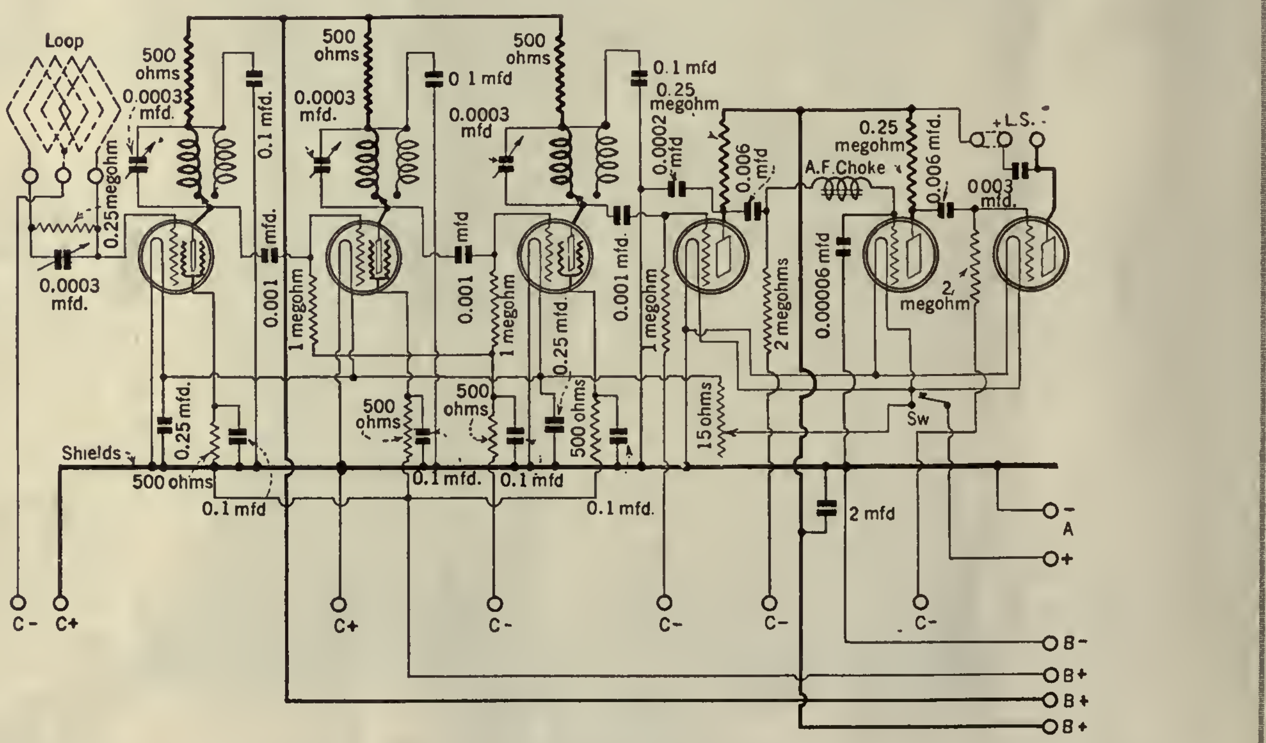
The system of screening is shown in the top view. Front, back, baseboards and sides of the cabinet are copper lined and there is a partition between each r.f. stage. A broad lip is formed round the upper edge of the screen and in this is laid a length of cable covered with braided copper and bonded to the metal at several points. To the underside of the cabinet top is secured a copper plate of sufficient size to complete the screening. When it is closed this plate is pressed into firm contact with the braided cable throughout its length, thus insuring a perfect electrical joint.

The four circuits—loop and three tuned circuit—are tuned by separate condensers arranged in pairs with edge control dials so placed as to be easily controlled with two fingers. As the circuits are accurately matched and not too sharply tuned (the selectivity of this receiver is probably insufficient for use in the United States—*Editor*) it is a simple matter to find a station by synchronizing at approximately the correct wavelength and operating all simultaneously. The dials are calibrated in meters.

There are two sets of astatic tuning coils covering 250-550 and 1000-2000 meters, the change-over being effected by multiple switches controlled by the "Range Switch" on the front panel.



THE ENGLISH SCREEN-GRID TUBE



THE CIRCUIT OF THE MARCONIPHONE MODEL 61

A Simple Unit for Measuring Impedances

By F. J. FOX and R. F. SHEA

MR. FOX and Mr. Shea have described in this article a very excellent use for vacuum tube voltmeters in the measurement of coils, condensers, and resistors that are ordinarily used in the audio-frequency and power circuits of modern radio receiving equipment. The circuit arrangement used is such that the unknown impedance is compared to a known resistance and at the balance point the unknown impedance is equal to the known resistance, whence we may easily calculate the inductance or capacity by the formulas given in the text. The comparative simplicity of the device is commendable, and since the device may be readily constructed for use in the home laboratory we feel that the article will appeal to our many friends who have shown such great interest in the descriptions of home laboratory equipment that have appeared in RADIO BROADCAST.

—THE EDITOR.

THE COMPLETED UNIT

All the instruments used in making the measurement are housed in this box, with the exception of the decade resistance box, which is connected in the circuit by means of terminals behind the rear tube. The C batteries are also housed in the box.

IN THE design of radio equipment there are many instances when it is desirable or necessary to know the impedance of large inductances or capacities which are used in the building of a piece of apparatus—for example, a B-power unit. Large inductances and capacities may, of course, be measured on a bridge (an expensive piece of apparatus) but in many cases, especially where the necessary standards of inductance and capacity are not at hand, the method to be described will be found useful, accurate, and inexpensive.

Most methods of measuring large impedances require the use of expensive apparatus and delicate instruments. The authors have aimed, in the method described here, to provide a simple, accurate and inexpensive method of measurement.

The apparatus utilizes vacuum tube voltmeters and provides a quick and accurate means of measuring impedance. The accuracy of the method is limited only by the precision of the meters used and the care used in making the instruments. With inexpensive instruments this device will give results to three figures and therefore is accurate enough for practical radio design work.

HOW THE UNIT WORKS

IT IS possible to measure high impedances by the use of a vacuum tube voltmeter in a circuit as indicated in Fig. 1. With this arrangement the vacuum tube voltmeter is used to read the voltage across the unknown impedance, and the current through the impedance is read by the milliammeter. The impedance is then equal to the voltage divided by the current. From the standpoint of simplicity this method has two disadvantages: it is necessary that the vacuum tube voltmeter be calibrated to read voltages, and an a.c. milliammeter—an expensive and delicate instrument—is necessary. To eliminate these disadvantages the circuit shown in Fig. 2 has been devised. In this case two vacuum tube voltmeters are used, one across a variable resistance, R, and another across the unknown impedance, Z, connected in the circuit at X. To calibrate this set-up a known value of resistance is first connected at X. The resistance box, R, is then set exactly equal to the known resistance so that the voltages across the two voltmeter circuits will be exactly equal to each other. A.C. voltage from the transformer, T, is then applied and the readings of the vacuum tube voltmeters as indicated by the meters, M_1 and M_2, are carefully taken.

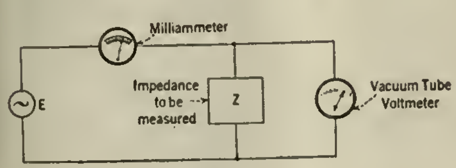


FIG. 1

The tubes for the set-up should preferably be very nearly matched so that when calibrating, the meter readings are very nearly alike for voltages of the order of those being used. That is, with the two equal resistances in place, the input voltage should be varied by means of the variable resistance in the primary of the supply transformer, T, and the meter readings noted. Tubes should be selected which give meter readings that correspond very closely over the entire range of voltages. From this calibration we know the corresponding readings of the two meters at any points on their scales under the condition that the voltage impressed across the input of each vacuum tube voltmeter is the same. The calibration is complete and we can now use the circuit to measure unknown impedances.

The unknown impedance to be measured is connected at X in place of the known resistance and the resistance of R is varied until the readings of the two meters correspond. We know from our calibration that when the readings correspond the voltages across the two vacuum tube circuits are the same. It therefore follows that under the condition that the readings of the two meters correspond, the voltages across resistance R and the unknown impedance are the same. Since the current through R and through the unknown impedance at X is the same it follows that

$$IR = IZ$$

where

I is the current

R is the value of resistance at which the readings of the meters corresponded

Z is the value of the unknown impedance

Therefore the impedance Z is equal to the resistance R.

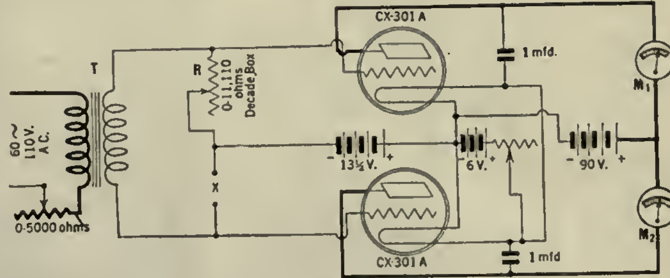


FIG. 2

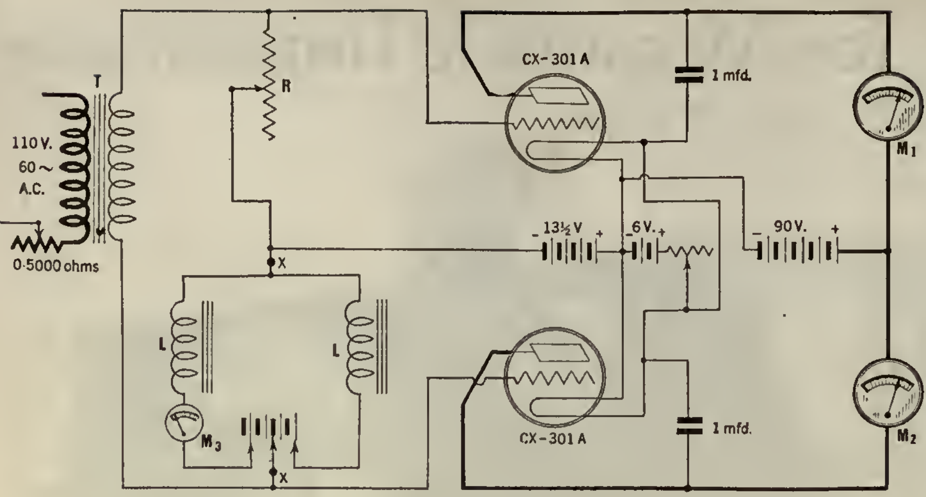


FIG. 3

Thus we obtain directly a value for Z in ohms. If then the d.c. resistance is obtained on a Wheatstone bridge the inductance is easily obtained from well known laws. In the case of large condensers the resistance may be safely neglected.

For inductances:

$$Z = \sqrt{\omega^2 L^2 + R^2}$$

$$\text{or } L = \sqrt{\frac{Z^2 - R^2}{2\pi f}}$$

$$\text{At 60 cycles } L = \sqrt{\frac{Z^2 - R^2}{377}}$$

where

z=impedance in ohms
$\omega = 2\pi f = 6.28$ times the frequency in c.p.s.
L=inductance in henries
R=resistance of the coil in ohms

In the case of a condenser the following holds true:

$$\text{At 60 cycles} \quad z = \frac{10^6}{\omega c} = \frac{10^6}{2\pi f c} \qquad c = \frac{10^6}{377z}$$

Where

z=impedance in ohms
c=capacity in microfarads

THE CONSTRUCTION OF THE UNIT

WE SHALL now describe this set-up, Fig. 2, in greater detail. Resistance R is a variable decade resistance box (such as those made by General Radio Company). This box has steps of units, tens, hundreds and thousands. The tubes used in the vacuum tube voltmeter are of the CX-301A type and should preferably be matched to give identical readings on the calibrating set-up so as to facilitate measurements. A 90-volt B battery is used in conjunction with 13½ volts of negative C bias. This bias drives the operating point well down to the lower knee of the plate-current-grid-voltage characteristic of the tube so that a small applied voltage gives a relatively large change of plate current. The meters, M_1, and M_2, are of Weston or Jewell 0–1.5 d.c. milliampere type. If the a.c. voltage from the transformer is about 12 volts the plate current of each tube will be about 1 milliampere and this is a convenient value to use. The transformer T which furnishes the measuring voltage should deliver about 12 to 14 volts, and a 5000-ohm heavy duty Bradleyohm or similar variable resistance is inserted in its primary.

The photograph at the beginning of this article shows a typical layout of the testing apparatus described above. The vacuum tubes, meters M_1 and M_2, exciting transformer, T, by-pass condensers and C batteries are housed in the box. The box should be so arranged that the C batteries may be easily replaced when necessary. The knob of the 5000-ohm variable resistance which is used to control the exciting voltage is placed in a convenient position outside of the box between the two tubes. The cable at the left goes to the 110 volt a.c. source, and the cable at the left to the batteries. The impedance to be measured is connected in the circuit by means of the two binding posts on the front. Two similar terminals in the back are used for connecting in the decade resistance box.

The resistance used at X for calibration should be about 1000 ohms and unless it is a standard resistance it will have to be measured carefully on a good bridge and labeled.

If greater accuracy is required higher grade meters than the ones described will have to be used; however, the small meters are accurate enough for all practical purposes.

WHEN BIASING CURRENT IS PRESENT

IT HAS been pointed out that it is frequently necessary to find the impedance or inductance of a filter choke coil, an impedance coil, or the primary of an audio-frequency transformer when certain values of direct current are flowing through the windings. Or it may be necessary to study the effect of various values of direct current on the inductance of a coil when the turns are varied or the air gap changed. A circuit which is used for this purpose is shown in Fig. 3. In this case a network consisting of two identical coils, L and L (under test), a milliameter, M_3, and a storage B battery is connected at X–X. The terminals of the B battery should be accessible so that various voltages may be tapped off. It should also be in good condition and all cells should show the same terminal voltage. As may be seen from the diagram the battery produces a circulating current around through the two coils, but since terminals X–X are connected to the midpoint of the battery and of the choke coils no potential exists between these points. When changing the amount of circulating current it is very important that this condition be maintained, otherwise the grid bias on the vacuum tube voltmeter, M_2, will be changed and a serious error will result. In case there is any doubt it is well to check the voltages on each side of the midpoint with a high grade voltmeter. Another way to check this is to take a reading of the vacuum tube voltmeter, M_2, when no a.c. is impressed and when no biasing current is flowing (battery cut out of circuit). Another reading is then taken with no impressed a.c. but with battery voltage of the desired amount in the circuit. If the vacuum tube voltmeter reading, M_2, does not change then the battery is not affecting the voltage balance, and the test may proceed.

Storage B batteries will deliver up to about 150 milliamperes. If more current is desired through the coils under test it will be necessary to use regular storage batteries.

Impedances measured in the manner indicated in Fig. 3 will be equal to one half the impedance of a single choke coil. Multiply the measured value by two and proceed to compute the inductance as outlined in the equations above.

Book Review

EXPERIMENTAL ELECTRICAL ENGINEERING AND MANUAL FOR ELECTRICAL TESTING. By V. Karapetoff. Third Edition, Revised and Enlarged, in Two Volumes. Vol. I, xxxii and 795 pages, 6 by 9, 391 figures, $6.00. Vol. II, xxxii and 618 pages, 280 figures, $5.00. John Wiley & Sons, New York.

IN ISSUING the third edition of Karapetoff's famous work on "Experimental Electrical Engineering" in a revised and reset printing John Wiley & Sons are performing about the same service for the electrical engineering profession at large as when they made Morecroft available in a second edition to radio engineers.

About the book little remains to be said. The author has been Professor of Electrical Engineering at Cornell University since 1904 He is one of the group of American electrical engineers, like Steinmetz, Pupin, Pender, Ryan and others, who have advanced the profession by their work both in the universities and outside, and who have in several cases combined notable literary and artistic talents with engineering ability. The two volumes of "Experimental Electrical Engineering" contain about all that the engineer wants to know about electrical testing and the practical behavior of electrical machinery. If he is interested in the process of getting the magnetization curve of an iron sample by the bismuth spiral method he will find it, in the same chapter with the Thompson permeameter, the Du Bois balance, the Koepsel permeameter, and the Ewing Permeability Bridge, in the first volume. If he happens to have gone into the talking movie field to find, perhaps to his surprise, that oscillograph galvanometers are used in some of the sound-movie recorders, he can read up on the applications and physical behavior of such devices in the second volume, where the electromagnetic oscillograph, its galvanometer, optical system, recording apparatus, electrical circuits, transient visualizer, and possible accessory apparatus, such as vacuum tube amplifiers, are quite completely described. The radio engineer will find a chapter on high-frequency measurements. Everybody in the profession will find something, and usually a lot, about what he wants to know. The treatment is packed with valuable references and numerical data. On assuming a new job recently, one of the first things I did was to order copies of both volumes. I knew perfectly well that before long one of the engineers would refer to it and find out in short order something worth a great deal more to the company than the price of the books—and the 1413 pages would remain for more use of the same kind indefinitely, unless somebody who is not as honest as he is wise steals them for his private library.

—CARL DREHER.

A Six-Tube Screen-Grid Receiver

By McMURDO SILVER

Silver-Marshall, Inc.

THE receiver described here is one of the new models in the line of kits to be marketed this season by Silver-Marshall. It is an excellent and attractive receiver and the essentials are priced to make the eyes of the home constructor and professional set builder open wide. The complete receiver was tested in the Laboratory and it performed very well indeed "in all departments," as the sporting writers say. The "gain" of this set is high, which is advantageous when the user wants distance. It should be remembered, however, that no high-gain receiver can successfully be operated where there is much man-made or other interference. It is simple enough in conditions like that to cut down the gain and to tune to stations where signal level is above that of the noise. Additional constructional data is available from the manufacturers or from Radio Broadcast.

—The Editor.

THE new Screen-Grid Six receiver is a highly perfected development of the receiver known to readers of Radio Broadcast for three years as the Silver Six, Shielded Six, and Shielded-Grid Six. The new Screen-Grid Six takes full advantage of all meritorious features of its predecessors, and, like the latest of them, it employs three stages of high-gain r.f. amplification with screen-grid tubes.

In performance, the receiver will give 10 to 15 kc. selectivity, in almost any location, and will bring in from forty to one hundred stations in a single average evening's tuning. Such are the results that have been had with numerous models built to the new design operated in many different locations in and about Chicago during the early months of 1928. And yet it can be built at home for less than seventy-three dollars!

As an example, the log on this page was obtained in two hours' time in a typical residential location within a few miles of Chicago's twenty-odd local stations. All the stations listed were received on the loud speaker with practically "local" volume, using only a 35′ antenna.

Since the Screen-Grid Six design would seem to represent not only a new high level of radio receiver performance, but also a new low level in cost, almost regardless of performance, it is felt that a description of the engineering features of the design, together with other points of interest, will not be unwelcome to Radio Broadcast readers.

From an examination of the photographs and drawings it is seen that the Screen-Grid Six is a six tube t.r.f. receiver consisting of a three-stage radio-frequency amplifier using screen-grid tubes, followed by a detector and two-stage audio amplifier. In this respect it is not at all unusual (though at this writing there are known no ready-made sets incorporating the full advantages of screen-grid r.f. amplification.) If there is anything at all unusual about the set, it is the fact that the three r.f. tubes have been made to average about two hundred and fifty times the amplification obtained from this same number of 201A tubes in some receivers using an r.f. choke in the input. In addition, the audio gain is greater than that of the ordinary audio system of the same number of stages, due to the employment of the Clough audio system.

How this is done is easily seen by taking as a typical example a representative ready-made six-tube set costing about one hundred and fifty dollars. In this common type of set the first r.f. tube has its grid circuit connected across a small r.f. choke directly in the antenna circuit, across which is developed the signal voltage. This type of coupling gives no voltage step-up between antenna and first r.f. tube, and does not contribute in any way to selectivity. The first tube with the t.r.f. transformer that follows it shows an average amplification of less than 10 times between 200 and 550 meters (this figure is quite generous). The two additional r.f. tubes, with two more t.r.f. transformers, each give a gain of 10 per stage. Thus, 10 x 10 x 10 = 1000 shows the amplification between antenna and detector grid circuit.

LOG OF SCREEN-GRID SIX

Station	Location	Right Dial*	Kc.
WNBA	Forest Park, Ill.	1	1440
KSTP	St. Paul, Minn.	4	1360
WJKS	Gary, Ind.	6	1290
WGES	Chicago.	8	1240
WOK	Chicago.	12	1190
WJAZ	Chicago.	19	1140
WTAS	Elgin, Ill.	18.5	1090
WENR	Chicago.	23	1040
WTMJ	Milwaukee	24	1020
KMOX	St. Louis, Mo.	26	1000
WHT	Chicago.	28.5	980
KDKA	Pittsburgh	31.5	950
KFAB	Lincoln, Nebr.	32.5	940
KOA	Denver, Colo.	34.5	920
KFQB	Ft. Worth, Texas	36	900
WSM	Nashville, Tenn.	37	890
WLS	Chicago.	42	870
WEBH	Chicago.	47	820
WDAF	Kansas City	47.5	810
WOC	Davenport	50	800
WGY	Schenectady	51	790
WBBM	Chicago.	54	770
KWKH	Shreveport, La.	55	760
WTAM	Cleveland	57	750
WCCO	Minneapolis	59.5	740
WGN	Chicago.	62	720
WOR	Newark, N. J.	63.5	710
WLW	Cincinnati	65	700
WQJ	Chicago.	71	670
WJZ	New York	73	660
KRLD	Dallas, Texas	75	650
KFI	Los Angeles	77	640
WSB	Atlanta, Ga.	79	630
WCFL	Chicago.	82	620
WEAF	New York	84.5	610
KTHS	Hot Springs	86.5	600
WOW	Omaha, Nebr.	89	590
WFLA	Clearwater, Fla.	92	580
KYW	Chicago.	95	570
WHO	Des Moines	98	560
KSD	St. Louis, Mo.	100	550

* *Reading of left dial is not given, since it varies a few degrees for different antenna lengths. Both dials "track" very closely.*

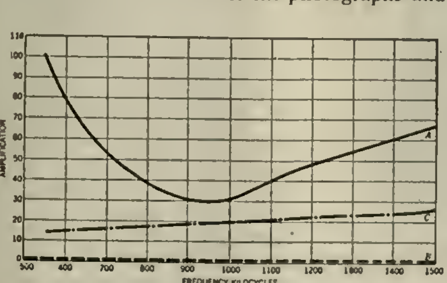


FIG. 1

For the Screen-Grid Six a tuned antenna input circuit was designed having the very best possible characteristics which could be attained in practice. This circuit consisted in its final form of a very low resistance coil consisting of 89 turns of No. 20 enameled wire upon a threaded bakelite form $3\frac{1}{4}''$ long and $2\frac{1}{2}''$ in diameter. A tap on this coil about 40 turns from the filament end is used when the set is to operate with a small antenna; when a long antenna is used or greater selectivity is required the antenna is connected to this tap through a 75-mmfd. midget condenser. Any student familiar with average coil resistance will realize that the values of 3.3 ohms at 550 meters and 11.5 ohms at 200 meters obtained with the coil, tuned by a 0.00035-mfd. condenser, represent an unusually good circuit (the coil itself has a "figure of merit" practically double that of the best coils on the open market). This input coil, L_1 in Fig. 7, is tuned by a single condenser, C_1, actuated by the left-hand drum, D_1.

In a test made to determine the characteristics of the antenna circuit, a representative antenna of 400 mmfd. capacity, 25 ohms resistance and 28 microhenries inductance was coupled to the input coil first through a small primary coil of 20 turns, and then through a large primary of 35 turns in series with a 75-mmfd. midget condenser, which was employed to regulate selectivity. Curve A of Fig. 1 shows that the voltage step-up provided by this tuned antenna input circuit varies from 64 at 200 meters (1500 kc.) to 28 at the middle of the broadcast band and rises to 100 at 550 meters (545 kc.)! And 545 kc. is the point at which the greatest step-up is always needed, for the amplification of any practical r.f. amplifier always falls off at long waves, as will be shown. The shape of this curve is not wholly ideal, but there is certainly no comparison between the voltage amplification that can be had from this circuit, with its one additional tuning dial, as compared to curve B of Fig 1. (Curve B represents the voltage amplification of a good untuned antenna coupling choke, and is hardly distinguishable from the base line of the curve of Fig. 1.) The dip in the center of curve A shifts with different size antennas and may further be shifted by adjustments of the midget antenna coupling condenser, C_6, so that it is seldom necessary to operate the receiver with as low a voltage step-up in the antenna coupler as is shown by the lower bend of curve A.

THE R.F. AMPLIFIER

THE antenna input circuit is followed by three identical tuned circuits, each housed in individual copper shielding cans, SH_1, SH_2, SH_3. These circuits employ small plug-in inductances, L_2, L_3, L_4, the secondaries of which consist of $98\frac{1}{2}$ turns of No. 29 enameled wire wound upon a threaded moulded bakelite form $1\frac{1}{2}''$ in diameter

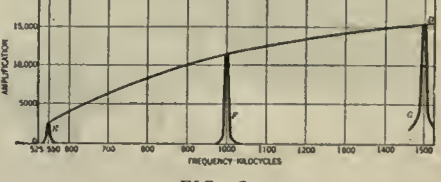


FIG. 2

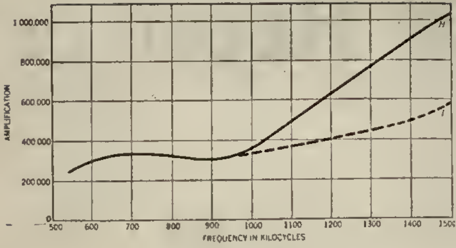


FIG. 3

and $1\frac{1}{2}''$ long. The primaries of the r.f. transformers consist of 50 turns of No. 38 enamelled wire on a piece of $1\frac{1}{4}''$ diameter tubing slipped inside of the secondary form. Two of these tuned circuits feed the two remaining screen-grid amplifier tubes, S_5 and S_6, while the third circuit feeds the detector tube, S_9. The actual measured voltage amplification of one individual stage is shown in curve C, Fig. 1, and is seen to vary from 14 per stage at 550 meters (545 kc.) to 25 at 200 meters (1500 kc.). While this amplification may seem very low for a screen-grid r.f. amplifier stage, it must be borne in mind that the high amplification factor of screen-grid tubes has no direct bearing upon the actual amplification that may be obtained from them in practice; that the maximum voltage gain which can be had from these tubes in the broadcast band with practical circuits will vary between 30 and 65 per stage, but that in order to obtain such amplification selectivity must be thrown to the winds. In the Screen-Grid Six, this has purposely not been done and the effective amplification of the three shielded r.f. amplifier stages has been purposely held at a low value in order that maximum possible selectivity could be obtained in these circuits. The overall voltage amplification of the three screen-grid stages, neglecting the antenna coupler, is shown by curve D of Fig. 2, and will be seen to vary from 2500 times at 550 meters to 15,500 times at 200 meters (curve D is simply the cube of curve C of Fig. 1).

An important thing to note at this point is the relative selectivity of the three-stage r.f. amplifier unaided by the antenna circuit (which contributes a very high degree of selectivity in itself). The selectivity curves in Fig. 2 do not show that the receiver is, like all t.r.f. sets, inherently non-selective at the lower frequencies. In curve H, Fig. 3, is shown the calculated r.f. amplification from antenna to detector grid for the Screen-Grid Six. (This amplification was calculated because of the practically impossible task of measuring the overall gain of such a sensitive receiver.) The curve is based upon the actual measured amplification for individual amplifier stages, and corresponds to curve D multiplied by curve A. Inasmuch as regeneration is not seriously present on the longer wavelengths (low frequencies) there is every reason to believe that the curve represents the actual performance of the receiver above 300 meters (1000 kc.). The rapid rise in amplification of the calculated curve below 300 meters is offset by the fact that on these lower waves there is a tendency for the receiver to oscillate, which is in turn offset by reducing the potential on the screen grids of the r.f. amplifier tubes by adjusting the potentiometer, R_1. The effect of this reduction is to increase the plate impedance of the r.f. tubes, which, in turn, decreases the effective amplification and increases the effective selectivity. The net result is a flattening off of the overall amplification curve much as shown by the dotted lines of Curve I, Fig 3, (curve I represents the actual performance of the receiver). It is seen to be quite flat, though the individual curves composing it were anything but flat to start with.

Before passing on from the r.f. amplifier, it is well to mention that every precaution has been taken to render the performance of this portion of the receiver as stable and dependable as possible. This can easily be realized from an examination of the illustrations and diagrams, which reveal individual copper stage shielding for the tuned r.f. amplifier circuits, individual bypassing of all B-supply leads by condensers directly in the stage shields, and the isolation of all r.f. currents from any common paths which might cause coupling and instability. The antenna input circuit is thoroughly shielded from the three remaining r. f. circuits, and when the receiver cabinet is in place, it is thoroughly shielded from extraneous interference. In order to allow for compensation of varying antenna characteristics, the option of two methods of antenna coupling is provided. One method employs a variable selectivity control in the form of a 75-mmfd. antenna series condenser, C_5. In the other method the condenser is omitted, and the antenna taps the primary coil, L_1, directly. The single tuning condenser, C_1, tunes the antenna circuit, and the triple gang condenser, C_2, C_3, and C_4, tunes the three remaining r.f. circuits housed in shields SH_1, SH_2, SH_3. Three compensators on the condenser frame allow compensation, once the set is assembled, for variations in tube and circuit capacities. Oscillation over the lower portion of the broadcast band, and volume over the entire band, is controlled by the potentiometer, R_1, which varies the potential on the screen grids of the r.f. amplifier tubes, S_4, S_5, S_6. The detector, S_9, presents no unusual features, being the conventional grid-condenser, C_{13}, and leak, R_7, type with negative filament return, since this was found to give best results in the Screen-Grid Six.

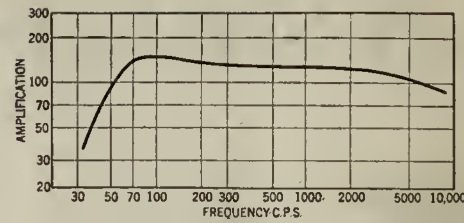


FIG. 4

THE AUDIO CHANNEL

THE transformers employed in the a.f. amplifier, T_1 and T_2, will be seen to consist of auto-transformers, resonating condensers, and plate resistors, all sealed in individual cans. These transformers have an effective transformation ratio of about 4.3 for T_1, and 3.5 for T_2, and through a unique phenomena of resonance obtained from proper proportioning of the auto-transformer windings, the condenser and the resistance, together with the plate resistance of the tubes used, a rising low-frequency characteristic is obtained which provides a hump in the amplification curve just below 100 cycles. (Fig. 4) A description of the audio amplifier system will be found in an article by Kendall Clough in the July issue of RADIO BROADCAST (pp. 133–4)

The effective voltage amplification of transformers T_1 and T_2 with a CX-301A or CX-112A first stage tube and CX-112A or CX-310 output tube would be approximately 960, a value much higher than is obtained from an ordinary transformer amplifier employing 3:1 transformers which would give a voltage gain of only 575 times as well as a bad fall-off in low-frequency amplification. (For the benefit of the dyed-in-the-wool fan who may think to improve ordinary transformers by either choke or resistance parallel feed, let it be stated that this cannot be done by rule of thumb methods—the Clough system has to be carefully proportioned mathematically to attain the results shown in Fig. 4.)

The photographs, drawings, and parts list are clearly marked and keyed and require practically no explanation. Mechanically, the receiver consists of a pierced metal chassis $21\frac{7}{16}''$ long, $9\frac{15}{16}''$ wide, and $\frac{5}{8}''$ deep. On top of the chassis are fastened, at the left end, the antenna coil, L_1, the antenna tuning condenser, C_1, as well as antenna and ground binding posts BP_1, BP_2,

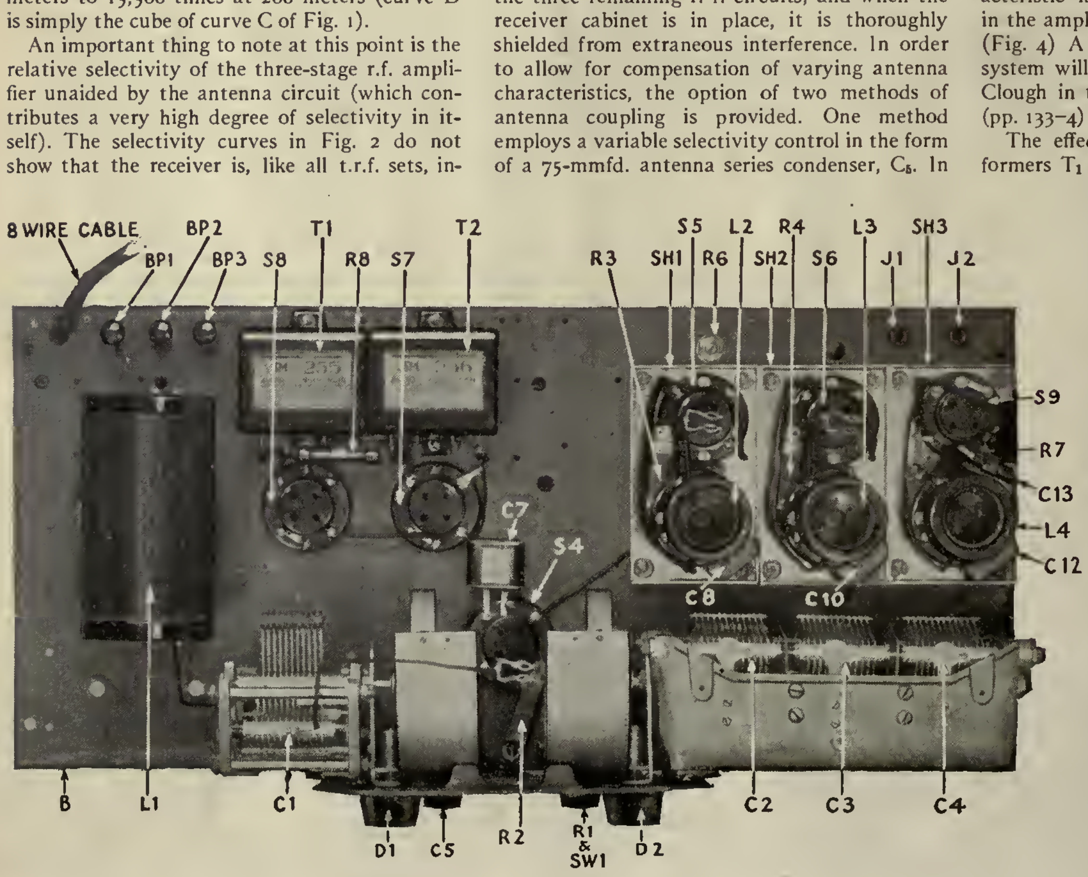


FIG. 5. ARRANGEMENT OF PARTS ABOVE SUB-PANEL

BP_3, and the hole for the battery cable. To the center rear of the chassis is the audio amplifier consisting of two transformers, T_1, and T_2, and two tubes, S_7 and S_8, with space left either for two large type transformers, or an output transformer in addition to the small types specified. To the right front is the three gang die-cast condenser, C_2, C_3, and C_4, tuning the three shielded r.f. circuits housed in the copper shields, SH_1, SH_2, SH_3, just behind this condenser. The two condenser assemblies are tuned by the drum dials, D_1, and D_2, visible through the windows of the front control escutcheon. Below the vernier knobs of the dials are, to the right, the volume control potentiometer, R_1, to which is attached the on-off switch, SW, and to the left is the selectivity condenser, C_6, in series with the antenna. The positions and uses of the various bypass condensers and resistors are evident from a study of Fig. 7. Just behind one of the copper stage shields is located a rheostat, R_6, used to compensate variations in A-battery voltage. It is intended to be adjusted by a screw-driver.

The receiver requires for operation three CX-322 tubes, one CX-301A (or preferably CX-112A) detector tube and one CX-301A (or preferably CX-112-A) first a f. amplifier tube. Any power output tube such as CX-112A, CX-371A, CX-310, or CX-350 may be used, provided suitable A and B supply is available. In the circuit shown, a CX-112A or CX-371A output tube may be used at will, though with the latter the addition of an output transformer is desirable to protect speaker windings. Either batteries or standard light socket power units may be used to operate the receiver. The plate current consumption is about 30 mA with 112A output tube, or 40 mA with 371 output tube. Hence a B-power device should prove more economical for operating the receiver, especially if a 371 tube is used.

Some may want to operate the set from the light socket through the use of a.c. tubes. In such cases heater type a.c. screen-grid tubes should be used in the r.f. stages and ordinary three electrode heater type 227 tubes in the detector and first audio stages. The output tube may be any type, with its filament operated from a.c. Complete circuit diagrams for a.c. operation can be obtained though RADIO BROADCAST or directly from the manufacturer. For a.c. operation some changes in the circuit and parts required for the construction of the receiver will be necessary.

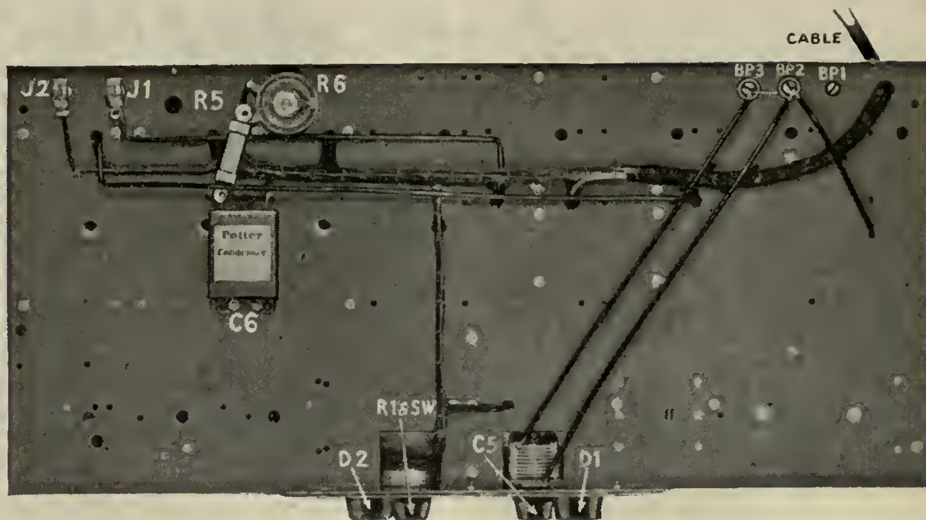
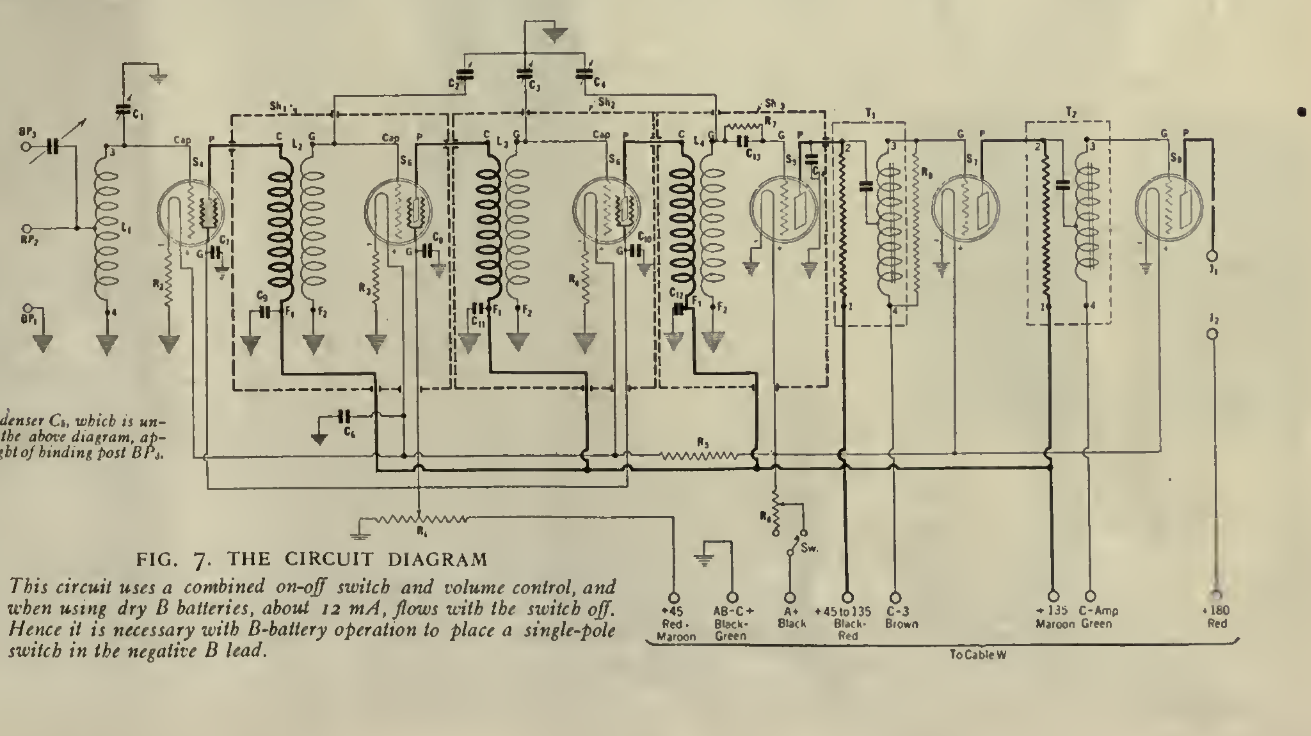


FIG. 6. UNDER THE SUB-PANEL

LIST OF PARTS

THE complete kit for this receiver may be obtained from Silver-Marshall, Inc., including a drilled chassis and all the necessary hardware. The special parts used in the circuit are the antenna coil, L_1, the r.f. transformers, L_2, L_3, and L_4, and the audio transformers, T_1 and T_2. The specifications of the antenna and r.f. coils are given in the article, and may be made at home. It is not advisable to substitute for the audio transformers, since the advantages of the Clough system of audio amplification, as described in the article, will be lost. The remainder of the parts in the list below are of standard design, and other parts electrically and mechanically equivalent may be substituted.

B—1 S-M Universal pierced base chassis, No. 701
E—1 S-M dual control escutcheon, No. 809
D_1—1 S-M vernier drum dial (left), No. 806L
D_2—1 S-M vernier drum dial (right), No. 806R
C_1—1 S-M 0.00035-mfd. Universal condenser, No. 320R
C_2, C_3, C_4—1 S-M 0.00035-mfd. 3-gang condenser, No. 323
C_6—1 S-M 0.000075-mfd. midget condenser, No. 342B
R_1—1 Yaxley 3,000-ohm midget potentiometer, type 53000
SW—1 Yaxley switch attachment, type 500
J_1, J_2,—2 Yaxley insulated tip jacks, type 420
R_1, R_2, R_3—3 Carter 10-ohm resistors type RU10
R_5—1 Carter $1\frac{1}{2}$-ohm resistor, type H$1\frac{1}{2}$
R_6—1 Carter 6-ohm sub-base rheostat, type A6
C_6—1 Potter 1-mfd. bypass condenser, No. 104
C_7, C_8, C_9, C_{10}, C_{11}, C_{12}—6 $\frac{1}{4}$-mfd. midget bypass condensers
C_{13}—1 0.00015-mfd. grid condenser with clips
C_{14}—1 0.0002-mfd. bypass condenser
R_7—1 2-megohm grid leak
R_8—1 Durham 0.15-megohm resistor with leads
SH_1, SH_2, SH_3—3 S-M copper stage shields, No. 638
L_1—1 S-M antenna coil, No. 140.
L_2, L_3, L_4—3 S-M plug-in r.f. transformers, No. 132A
S_1, S_2, S_3,—3 S-M 5-prong tube sockets, No. 512
S_4, S_5, S_6, S_7, S_8—5 S-M tube sockets, No. 511
S_9—1 Naald cushioned tube socket, type 481XS
T_1—1 S-M first stage a.f. transformer, No. 255
T_2—1 S-M second stage a.f. transformer, No. 256
BP_1, BP_2, BP_3—3 Moulded binding posts consisting of $\frac{8}{32}$ screw, nut, and moulded top.
1 S-M 708 8-lead, 5-foot connection cable
1—S-M 818 hook-up wire (25 ft. to carton)
1 Set hardware (obtainable from Silver-Marshall)



Note: Condenser C_6, which is unlettered in the above diagram, appears to right of binding post BP_3.

FIG. 7. THE CIRCUIT DIAGRAM

This circuit uses a combined on-off switch and volume control, and when using dry B batteries, about 12 mA, flows with the switch off. Hence it is necessary with B-battery operation to place a single-pole switch in the negative B lead.

New Apparatus

PRODUCTS of radio manufacturers whether new or old are always interesting to our readers. These pages, a feature of Radio Broadcast, *explain and illustrate products which have been selected for publication because of their special interest to our readers. This information is prepared by the Technical Staff and is in a form which we believe will be most useful. We have, wherever possible, suggested special uses for the device mentioned. It is of course not possible to include all the information about each device which is available. Each description bears a serial number and if you desire additional information direct from the manufacturer concerned, please address a letter to the Service Department,* Radio Broadcast, *Garden City, New York, referring to the serial numbers of the devices which interest you, and we shall see that your request is promptly handled*—The Editor.

Power Apparatus for the 250 Type Tube

X52

Device: Power Supply Apparatus for use with the type 250 tube. In constructing a power unit to use the type 250 tube it is essential that apparatus be used that will be capable of supplying to the tube sufficient current and voltage. There is given below a *résumé* of power apparatus, old and new, made by several manufacturers which may be used satisfactorily to operate a power amplifier using a type 250 tube.

Amertran Power Transformer, Type PF 250. *Price:* $30.00. Gives a d.c. output of 400 to 450 volts, 200 mA., with two type 281 rectifying tubes, full-wave; either one or two power tubes, type 250, single or push-pull, can be used. Filter Choke Coil, type 709. *Price:* $6.00 each. Inductance: 50 henries at 120 milliamperes.

Dongan Power Transformer, Type 7568. *Price:* $13.00. Designed for full-wave rectification using two type 281 rectifiers. Double Filter Choke Coil, type 5554. *Price:* $11.00.

National Power Transformer, type R. *Price:* $14.50. Designed for full-wave rectification using type 281 rectifiers. Filter Choke Coil, type 80. *Price:* $10.00.

Samson Power Transformer, type 162. *Price:* $18.00. Designed for half-wave rectification using type 281 rectifier. Filter Choke Coil, type 312, 30 henries, 120 mA. *Price:* $12.00.

Silver-Marshall Power Transformer, type 328. *Price:* $18.00. Designed for full-wave rectification using type 281 rectifiers. Type 327 (*Price:* $12.00) may be used in half-wave circuits. Filter Choke Coil, type 331. 27 henries, 120 mA. *Price:* $8.00.

Thordarson Power Transformer, type T 2900. *Price:* $20.00. For full-wave circuit using two type 281 tubes. Double Filter Choke Coil, type T-20-99. *Price:* $14.00.

Application: The above apparatus is for use in constructing power amplifiers using the type 250 tube. The General Radio Company also manufacture apparatus for this purpose and their units were described in this section in the June issue. Further information including circuit diagrams, can be obtained from the above manufacturers through Radio Broadcast.

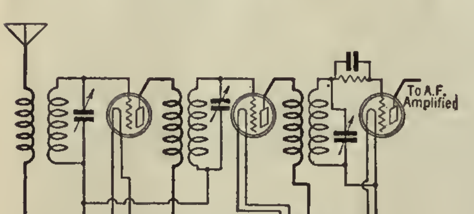


FIG. 1

One use of the Duplex Clarostat is, as shown in this diagram, to control the plate voltage applied to either tube of a two stage radio frequency amplifier

THE DUPLEX CLAROSTAT

A Dual Resistance with Many Uses

X53

Device: Duplex Clarostat Resistance. A novel form of resistance consisting essentially of two Clarostat resistances in a single metal case. Each section can be independently adjusted to any value of resistance within the range of the Clarostat, which is from a low resistance to a high resistance of about five million ohms. Resistance is varied by tuning a slotted screw with an ordinary screw driver. May be mounted on panel, sub-panel or baseboard. Furnished with mounting bracket. *Manufacturer:* Clarostat Manufacturing Company. *Price:* $2.25.

Application: The instruction sheet supplied with each Duplex Clarostat points out many uses for the device. These include its use in resistance-coupled amplifiers, in push-pull amplifiers, as a plate voltage control, as a center-tap resistance, etc. In Fig. 1 and 3, which illustrate two of these uses, the Duplex Clarostats have been enclosed in dotted lines.

Aluminum Shields

X54

Device: Aluminum Box Shields. Designed for use in constructing shielded receivers. Two sizes are available; the Junior size measuring 4½ x 4½ x 5 inches high and the large size measuring 5 x 9 x 6 inches high. The Junior shield has room for a coil and a tube; this shield is for use with a metal sub-panel and is not supplied with a bottom the large shield can be used to house the coil, tube, and tuning condenser. The shields are made of 0.08- inch thick aluminum, and they consist of four sides, top, bottom, and two slotted corner posts into which the sides are fitted. *Manufacturer:* Aluminum Company of America. *Price:* $8.00 for set of four Junior shields, $3.50 each for large shields.

Application: Shielding is of importance to radio amateurs who wish to improve their present outfits or who have decided to incorporate shielding in new equipment of their own design.

Reviewing the circuits generally used, a single-tube receiver with regenerative detector usually is not improved by shielding, unless it happens to be located very close to a broadcasting station. In this case the entire detector circuit, including the coil, the tube socket, and the tuning condenser, may be mounted advantageously inside a standard aluminum box shield.

In a receiver employing one stage of radio-frequency amplification and a regenerative detector, the detector circuit may be shielded completely. If this is done there is little additional advantage in shielding the radio-frequency stage.

A circuit using two stages of radio-frequency amplification may be improved slightly by using shields of the partition type. Where selectivity and stabilization are especially necessary, the coils, tube sockets, and condensers may be mounted in shields. The apparatus of one stage only should be placed inside a single box, separate boxes being used for additional stages. An alternative is to place the coils and tube sockets of each stage in Junior Shields with the tuning condensers outside of the shields.

For circuits employing three stages of radio-frequency amplification, it is recommended that each stage, including the condensers, be housed in a standard box shield, or the Junior size shields may be used for covering the coils and tube sockets only.

For super-heterodyne circuits, in which the maximum of selectivity is desired, it is advisable to shield the entire first detector circuit in a box-type shield and the entire oscillator circuit in a similar unit.

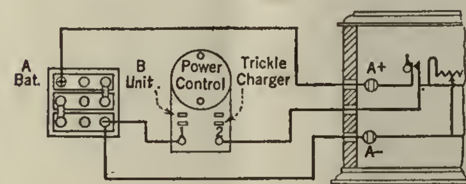


FIG. 2

Automatic Control for A and B Power

X55

Device: Multiple Type 445 Automatic Power Control. Designed especially for use with radio receivers drawing a filament current of less than about 0.36 amperes (corresponding to the current required for six 199 type tubes). The Yaxley type 444 control should be used if the receiver has a total current drain of more than 0.36 amperes. This type 445 control automatically turns off the trickle charger and turns on the B-power unit when the filament switch on the

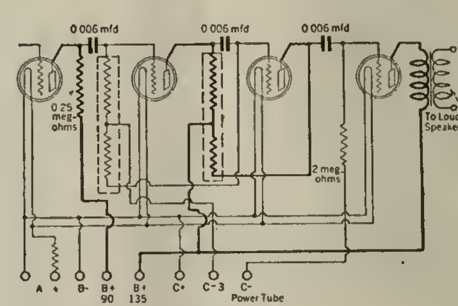


FIG. 3

A second use for the double resistance described above in X53 lies in controlling the plate voltage to two tubes in a two or three stage audio amplifier. Another Duplex Clarostat may be used to control the grid leak resistance of the two tubes

THE MAGNAVOX SPEAKER, TYPE D-80

receiver is turned on. When the set is turned off, the power control turns off the B-power unit and turns on the trickle charger. The connection of this control to a radio receiver is shown in Fig. 2. *Manufacturer:* Yaxley Manufacturing Company. *Price:* $6.00.

Application: As mentioned above, the power control is designed especially for use with radio receivers using six 199 type tubes or less. By its use the charging of the battery is automatically taken care of while the radio receiver is not in use and there is no possibility that the B-power unit will be left turned on while the set is not in use.

Dynamic Speakers for A.C. and D.C. Operation

X56

Device: Magnavox Dynamic Loud Speakers. The following types are available:

Type R-4. The field winding of this model requires 0.65 ampere at 6 volts. This energy may be supplied from a storage battery or any other source of 6 volts d.c.

Type D-8. This model requires 6 to 12 volts d.c. for field excitation. The field current at 6 volts is 1.1 amperes and at 12 volts 2.2 amperes.

Type D-80. The field circuit of this model is supplied through a transformer and rectifier from the 110-volt a.c. light socket. The hum due to the use of rectified a.c. is prevented by means of a neutralizing coil as explained below.

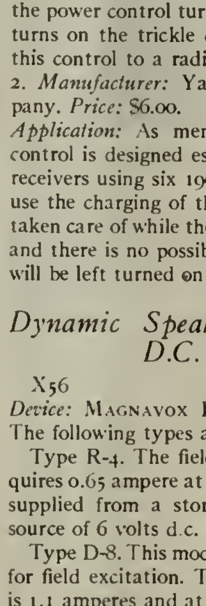


FIG. 4

All of the above models are identical in practically every way with the exception of changes associated with the particular method of field excitation which is used. In the case of the type 80 unit utilizing rectified a.c. for field excitation, an additional coil is wound on the moving element and the current through this extra coil neutralizes the effect of the pulsating current in the field winding. The resultant effect upon the cone is zero and therefore no hum is produced.

All of the models include an output transformer designed to adapt the impedance of the moving coil to that of the power tube. If it is desired to use one of these loud speakers in special circuits such as push-pull or a parallel arrangement of power tubes, special transformers are required. These transformers can be obtained from any of the well known manufacturers of audio frequency apparatus.

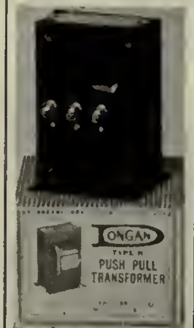
It is essential that a baffle be used with these loud speakers. Two waves are generated by the movement of a free edge cone, into which class fall speakers of this type. When the cone moves forward it compresses the air in front of it and at the same time decompresses or rarifies the air at the back of the cone and unless a partition is erected to keep these two effects separate they will tend to neutralize each other and lower the efficiency of the speaker. The baffle is especially necessary to obtain satisfactory reproduction of the low frequencies, for at high frequencies the cone itself acts as an effective baffle. The baffle may take the form of a cabinet or of a large flat surface. In either case the baffle itself should be so constructed that it will not readily vibrate. Otherwise it will produce exaggerated response at those frequencies at which the baffle resonates. In the Laboratory a large flat piece of wood measuring about four feet by four feet, and an inch thick, is used with excellent results. If a cabinet is used for the baffle the distance from the center of the front of the cone around the edge of the cabinet to the rear of the cone should be at least two feet. This distance is indicated in Fig. 4. The baffle should be left open at the back and in order to prevent undesirable resonance in the cabinet itself, it may be necessary that a few small holes be placed in the side and bottom.
Manufacturer: The Magnavox Company. *Prices:* Type R-4, $35.00; type 8, $35.00; type 80, $50.00 without cabinet.

Application: Present day dynamic speakers represent one of the most important developments in radio. Theoretically the dynamic speaker is capable of giving practically uniform response over the entire range of audio frequencies, and such uniform response is realized to a considerable extent in practice under good operating conditions. A dynamic speaker is now used in the Laboratory as a standard of comparison for it is capable of giving much better quality than other types of loud speakers available at present. Many will prefer to purchase only the unit and install it in a baffle consisting of a large flat board about one inch thick and preferably three or more feet square.

For Push-Pull Amplification

X57

Device: Push-Pull Audio Transformer, Type H. These transformers are for use with either 171 or 210 type tubes in push-pull amplifiers. The turns ratio of the input transformer is 1.75 to 1; the turns ratio of the output transformer is 1 to 1. *Manufacturer:* Dongan Electric Manufacturing Company. *Price:* $4.50 for the input transformer; $4.50 for the output transformer.



DONGAN PUSH-PULL TRANSFORMER

Application: The circuit diagram of a single stage push-pull amplifier using these transformers is given in Fig. 5. The tubes may be either 171's or 210's. The resistance, R, supplies C bias to the tubes; for 210's its value should be 750 ohms, for 171's its value should be 1000 ohms.

Fixed Resistances

X58

Device: Davohm, and Super-Davohm Wire-Wound Fixed Resistances. Davohm resistances are made in the following sizes; 7.5 watts (500 to 15,000 ohms), 15 watts (500 to 15 000 ohms),

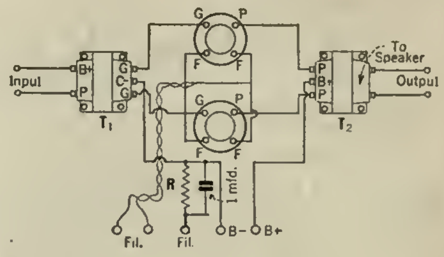


FIG. 5

1 watt (100 to 5000 ohms), 2 watts (100 to 7500 ohms). Super-Davohms have a rating of 1 watt and are available in sizes ranging from 10,000 ohms to 5 megohms. Manufactured by the Daven Radio Corporation. *Prices*, vary with rating of resistor.

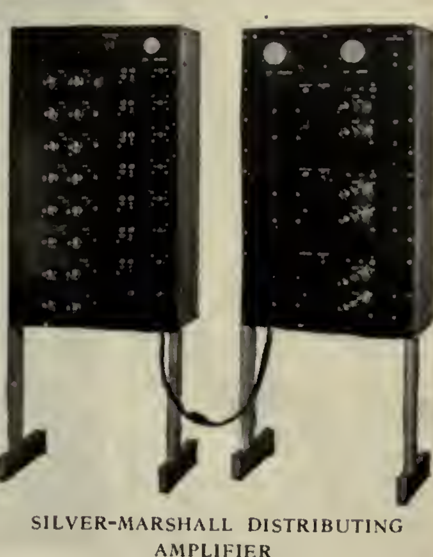
Application: May be used in any device where there is need for a good resistance. The Davohm resistances are excellent for use in all types of power units. Super-Davohms are useful as laboratory standards, multipliers for voltmeters, plate resistances in a. f. amplifiers, grid suppressors in r. f. amplifiers, etc.

A. C. Power Amplifier for Many Loud Speakers

X59

Device: Distributing Power Amplifier for apartment house use. The amplifier illustrated consists of eight 210 push-pull stages each operating ten loud speakers, with approximately 500 milliwatts per outlet. The eight amplifiers with their input panel are powered by three rectifier panels employing 281 type tubes, each of which delivers approximately 132 mils. at 450 volts, each rectifier operating three amplifiers. The complete installation is light-socket operated, and comes in a varying number of racks to take care of varying numbers of outlets. These racks need merely be interconnected by the plugs provided, the output of the radio receiver connected to the amplifier, and the power plug inserted in an a. c. light socket, and the installation is ready for operation. Manufactured by Silver-Marshall, Inc. *Price:* $300.00, approximately, for an amplifier suited to the operation of from four to ten loud speakers.

Application: This amplifier rack represents a development in equipment suited to public address or apartment house installation and the accompanying photograph shows a typical distributing amplifier—a good subject for a conversation with your landlord.



SILVER-MARSHALL DISTRIBUTING AMPLIFIER

A Non-Radiating Short-Wave Tuner

By JAMES MILLEN

RADIO BROADCAST has described in past months a number of interesting short-wave receiver units of various designs. The unit described here, a product of the National Company, contains no audio system—which makes it applicable to any audio system whether a part of a standard receiver or not. The set is non-radiating, and due to the isolation of the radio-frequency stage from the detector circuits, the tuning points as noted on the dial do not vary with antennas of varying lengths. The antenna circuit is choke-coupled to the screen-grid tube. A "picture diagram" of the set and most of the constructional data have not been included in this article because a blueprint of the hook-up and layout and constructional data are available through Radio Broadcast *or direct from the National Company.* —The Editor.

SYMMETRY AND SIMPLICITY IN THE FRONT PANEL

NOW that short-wave broadcasting has passed through its early experimental stages and reached the state where reliable reception of good quality programs is readily obtained by means of easily constructed and inexpensive receivers, a great many readers who in the past have confined their efforts to the construction of radio receivers for use on the regular broadcast band, desire to build a good short-wave receiver.

Aside from the mere fun of building a "different" type of radio set, there is that thrill of receiving understandable programs from distant and foreign stations. With a short-wave receiver, distance takes on an entirely new meaning.

It is not uncommon to receive broadcasting from ANE at Java, 3LO at Melbourne, Australia, 5SW at London, PCJJ in Holland, and many others; and static and fading are frequently entirely absent when reception on the regular broadcast band is exceedingly poor.

THE DESIGN OF THE RECEIVER

THE National Screen-Grid Short-Wave receiver comprises several interesting features. One is the single tuning control. Another is the foundation unit design which permits an efficient layout of parts, with but a few connections to be made by the assembler. As a result of the 222 type tube in the first stage, the sensitivity of the receiver in general is materially better than that of the plain regenerative detector type formerly so much in use. Furthermore, the use of the 222 tube ahead of the essential regenerative detector prevents radiation—a problem which would soon become quite serious if all the short-wave receivers were of the radiating variety. Still another important advantage secured by the use of the 222 tube as in this receiver is the elimination of tuning "holes," or dead spots commonly encountered with plain regenerative receivers. Although heretofore rather carefully placed shielding has been considered essential to a receiver using the 222 tube, the use of the untuned antenna circuit employed in this screen-grid short-wave receiver makes shielding unnecessary. The elimination of the shielding not only reduces the cost of parts and simplifies the work of construction, but also makes it a simple matter to change coils when going from one band to another. To cover the band of from 15 to 115 meters (20 to 2.65 megacycles) four interchangeable transformers are used. These transformers differ in a number of respects from the conventional "short-wave coils" with which everyone is familiar.

In the past it has been the general practice to employ coils of fairly large diameter—usually about 3 inches or so. As a result, all but perhaps the 100-meter coil would have a diameter much greater than its length. It is a well known fact that the most efficient coil is one having what is known technically as "unity form factor," or in other words a length of winding equal to the diameter. By using a coil diameter smaller than customary and at the same time varying the spacing between turns and size of wire, a coil of high efficiency for each band has been developed. In addition, in order to secure a high mutual inductance between the primary and secondary of the r.f. transformer without unnecessarily high capacity coupling, the primary or plate coil is wound of very fine wire located between the turns of the secondary or grid coil. The tickler winding in each instance is located in a slot at the low potential end of the transformer.

One of the most essential and most neglected features of a good short-wave inductance is rigidity. Without rigidity any slight vibration or jar in the room where the receiver is being operated will result in unsteady signals. Also, such coils will not stand up under continual handling, with the result that stations are seldom received from time to time at the same dial setting. In the case of these coils, such difficulties are entirely overcome by winding the transformers on threaded micarta tubing, and soldering the ends of each coil directly to the special one-piece contacts located around the bottom of the tube.

While some readers may think that the use of such a micarta tube would increase the losses in the coils by a noticeable amount, such has been found not to be the case, as the dielectric is located in the weakest part of the magnetic field of the coil.

Another interesting feature is the special tuning condenser employed. This condenser, while resembling in general appearance the standard National Girder Frame condenser, is one designed especially for use in short-wave receivers. In the first place, it has a straight frequency line characteristic, so as to make tuning equally easy at both ends of the dial. A further arrangement for facilitating tuning is the 270 degree rotation, which spreads the stations over 50 per cent. greater dial range than if the standard 180-degree rotation had been employed. The double plate spacing that will be noted from the illustrations, is employed to "smooth out" any slight irregularities in the characteristic curve of the condenser, which, while not ordinarily detectable at broadcast frequencies with

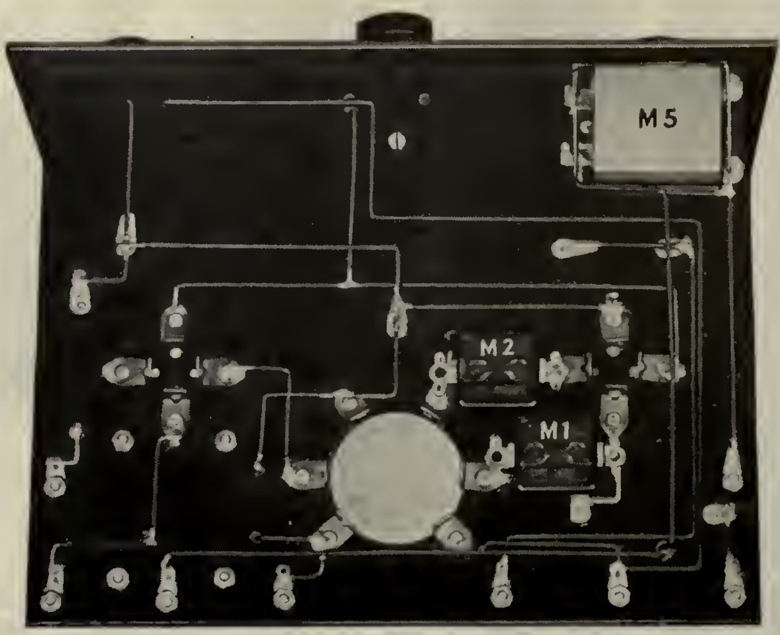


FIG. 1. UNDERNEATH THE SUB-PANEL

standard condensers, is quite noticeable at the short wavelengths.

A final innovation in the condenser design is a constant impedance pig-tail which eliminates variations in dial settings due to pig-tail inductance variations when the old style of "clock spring" contact is used.

The r.f. choke coil, G_1 in Fig. 2, used in the detector plate lead, is of the multi-section slot-wound variety having very low distributed capacity over a wide band of frequencies. The other r.f. choke, or grid circuit impedance, G_2, is one especially designed for the purpose and has an inductance of approximately 2 millihenries.

Perhaps it would be well to caution at this time against the use of the wrong size filament resistor, R_3, for the UX-222 tube. This resistor should be of the 15-ohm size and not 22 ohms. Due to the type number of the tube, UX-222, and the practice of some resistor manufacturers of marking their 22-ohm units as type 22, many experimenters have assumed that a "type 22" resistor is the proper one to use with a UX-222 tube under any conditions.

COIL DATA

THE four coils used in this set have wavelength ranges as follows:

Type A—15.5 to 26.5 meters. Secondary, 4 turns of No. 14 enameled wire; tickler, 2 turns of No. 30 d.s.c. wire; primary, 3 turns of No. 28 enameled wire.

Type B—23.5 to 41 meters. Secondary, 7 turns of No. 14 enameled wire; tickler, 2 turns of No. 30 d.s.c. wire; primary, 6 turns of No. 28 enameled wire.

Type C—37.5 to 65 meters. Secondary, 14 turns of No. 14 enameled wire; tickler, 3 turns No. 30 d.s.c. wire; primary, 14 turns No. 28 enameled wire.

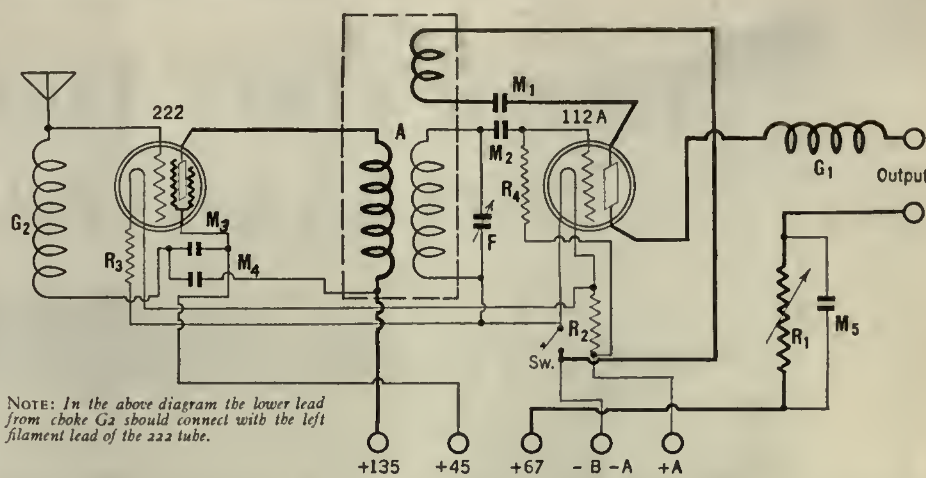
Type D—64 to 115 meters. Secondary, 25 turns of No. 18 enameled wire; tickler, 4 turns No. 30 d.s.c. wire; primary, 25 turns No. 28 enameled wire.

All of the coils are wound on 2 inch tubing. The secondaries of the first three types are spaced 8 turns to the inch; the secondary of D coil is spaced 14 turns to the inch. The tickler is wound in a slot $\frac{3}{8}''$ below the filament end of the secondary and the primary is wound in the spaces between the secondary turns.

CONSTRUCTIONAL NOTES

BY CAREFULLY studying the illustrations, one will readily see how to mount all of the parts on the foundation unit. All holes are drilled and the work is very easy. As soon as the assembly is completed the wiring may be done. If the wiring diagram is carefully followed it is quite simple for anyone to obtain a very neat job. Needless to say, all connections should be carefully soldered. The two moulded mica condensers located under the sub-panel, are fastened in place by soldering their terminals directly to the socket and coil clips between which they are connected.

In order to make contact to the cap or control grid of the 222 tube, use a short length of small, flexible, rubber-covered wire, or very fine single silk-covered wire, running in a piece of small spaghetti and ending in a fuse clip or similar home-made clip, to snap on at the top of the cap.



NOTE: *In the above diagram the lower lead from choke G2 should connect with the left filament lead of the 222 tube.*

FIG. 2. THE CIRCUIT DIAGRAM

AUDIO AMPLIFIERS

FOR headphone reception, it is recommended that a single stage of transformer-coupled audio amplification be added to the output of the receiver as just described. While such an additional amplifier is not at all necessary, it will be found of considerable aid in receiving distant and weak signals.

When loud speaker operation from such short-wave broadcasting stations as KDKA, WABC, etc., is desired, then the use is recommended of a high grade two-stage transformer-coupled audio amplifier of either the straight or push-pull variety.

LIST OF PARTS

THE complete parts, together with the foundation unit, may be obtained in kit form. However, all the parts, with the exception of the coils, are of standard des gn, and other equivalent parts may be substituted. The coil data is given in the text.

A—4 National short-wave transformer coils covering the range of 15 to 115 meters
E—1 National dial, type E, with type 28 illuminator
F—1 National condenser, short-wave type, 125 mmfd.
G_1—1 National r.f. choke, No. 90
G_2—1 National h.f. impedance, No. 10
M_1—1 Aerovox molded mica condenser, 0.001 mfd.
M_2—1 Aerovox molded mica condenser, 0.00025 mfd.
M_3, M_4—2 Aerovox bypass condensers, 0.5 mfd.
M_5—1 Aerovox bypass condenser, 1.0 mfd.
R_1—1 Electrad Royalty resistor, type L, 0–500,-000 ohms
R_2—1 Filament resistor, 2 ohms
R_3—1 Filament resistor, 15 ohms
R_4—1 grid leak, 6 megohms
S—1 Yaxley filament switch
8 Eby binding posts
1 Foundation Unit, including Westinghouse Micarta panels, sockets, gridleak and r.f. choke mounts, completely drilled, ready to assemble UX-222 and UX-201A tubes

OPERATION OF THE RECEIVER

AT THIS time, the writer feels that socket-power units are not suitable for use with a short-wave receiver. It is necessary for satisfactory results, therefore, to employ 135 volts of dry or storage B battery, in addition to the usual 6-volt storage A battery. If an audio amplifier of some kind is not to be employed, then a pair of phones should be connected to the "output" posts on the right-hand side of the sub-panel.

A good ground may be connected to minus A. In some instances, however, better results are obtained without the use of a ground.

For an antenna it is recommended to use a single wire of from 35 to 100 feet in length and as high and free from surrounding objects as possible.

By means of the variable resistance regeneration control (right-hand knob) the detector tube may be made to oscillate, and then the carrier of the station received. A slight readjustment of both controls should then bring in the station. The tuning of a short-wave receiver is a much more critical process than that of a standard broadcast receiver, and unless care is used, the novice is likely to pass right by a station.

Station 5SW at Chelmsford, England, can generally be heard between 5 and 6 P.M. in Boston when using transformer B and with the dial set at about 31.

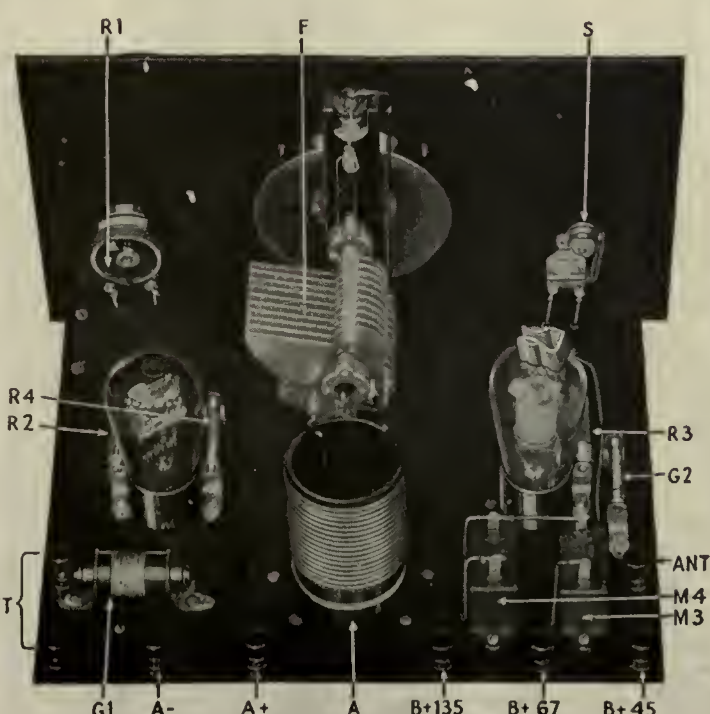


FIG. 3. ABOVE THE SUB-PANEL

What RADIO Has Done *for* AVIATION

By AN ENGLISH RADIO ENGINEER

An English answer to the charges made by "Anonymous" in the November number of this magazine, that aviation has not made the proper use of radio, points out the fact that in the "air-minded" countries of the Old World radio is playing its part in the safety of air navigation. The implication is that as America develops its commercial air lines to the point at which they are now developed in Europe, radio will be recognized as an essential part of airplane equipment.

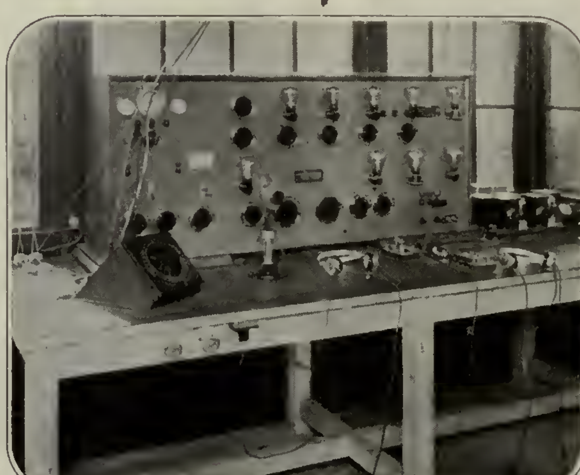
—THE EDITOR

MUCH has been said in the past about the failure of aviation to make the proper use of radio, particularly on such hazardous ventures as transoceanic flights. An unusually stimulating article on this subject by "Anonymous," entitled "What's the Trouble with Aircraft Radio?" appeared in the November, 1927, number of RADIO BROADCAST. As its title suggests, "Anonymous" is looking rather for what radio has not done for aircraft than what it has done. We may fairly claim that the latter is even more striking than the former.

No radio engineer who has had experience in aircraft radio would attempt to minimize the difficulties to be encountered in adapting radio to aircraft use, but that these difficulties are not insuperable has been proved time and time again since the institution in England, by the Marconi Company, of what I believe were the earliest experiments in this direction at that famous nursery of European aviation, the Hendon Airdrome near London. Incidentally, these "laboratories" were in the Graham White sheds at Hendon, so it cannot be said that the radio engineers were out of touch with the flying men. To-day the Marconi Company is working in close collaboration with the Air Ministry and aircraft operating and constructing companies, and has recently completed the construction of an entirely new installation at the London Air Port at Croydon, with four transmitters working on different wavelengths, which is claimed to be the most up-to-date airdrome radio installation in the world.

During the war the evolution of the radio telephone set for airplanes was pushed forward, and in the summer of 1915 the first spoken message from an airplane to the ground, in England, was obtained by Major Prince in collaboration with Captain H. J. Round—then members of the experimental section of the Royal Flying Corps at the Brooklands Wireless School—by means of a continuous wave tube transmitter. Continuous inter-machine working was not an accomplished fact until 1917, but it was used for formation control in the latter stages of the war.

In the last few years the development of radio for fighting planes has proceeded to a stage far in advance of that reached by November, 1918, with the result that the wonderful squadron "air drill" that may be seen in the world's leading air forces has become a practicable and safe proposition instead of—as it would be without radio—a hazardous adventure. For purposes of this "air drill" in close formation the Marconi Company has now developed a small, light set using an aerial system attached to the wings.



IN THE CROYDON RADIO CONTROL TOWER

The four transmitters at Mitcham, 4½ miles from the Croydon Air Port, are controlled from this room. At the left is the direction finding unit; next to it is the 9-tube multiwave receiver amplifier. Transmission takes place on telephony and telegraphy.

It is, however, to the enormous possibilities of civil aviation that the world is turning its eyes to-day; and no thoughtful person will quarrel with "Anonymous" when he says: "Before passengers are permitted to risk their lives, regulations regarding suitable radio equipment and personnel to operate it should be laid down." This state of affairs has already been reached in all the principal countries in Europe. But, before we examine more closely the working of this commercial aviation policy in Europe, let us look at some of the more spectacular achievements of radio—because "Anonymous" has selected some spectacular non-achievements.

WHERE RADIO HELPED THE FLYER

WHEN the British Airship R34 flew across the Atlantic in July, 1919, radio was used in a very practical manner by its navigators for direction finding and position finding. In addition the airship was in touch with the Air Ministry in London practically throughout its voyage, and during the whole time that it was over the Atlantic was never out of touch with land on one side or the other. Just what this would mean to a commercial air line of the future need not be emphasized. And there is another achievement in connection with radio on airships of which the radio engineer can justly be proud. In a heavy gale in April, 1925, the British military airship R33 broke away from its mooring mast at Pulham and floated off over the North Sea, driven by a furious wind. Thanks to the work of its radio operator, however, the airship was able to keep in touch with its base throughout the time of its involuntary flight. Officials there and at the Air Ministry knew all the time exactly what the position of the airship was and how it was faring. The information that they were able to give to Flight Lieutenant Booth, who was the chief officer in the airship at the time of the breakaway, as to his position and the extent of his drift

from hour to hour was undoubtedly one of the leading factors in assisting the gallant crew to pilot the damaged airship safely back to land.

The *Norge* also found radio of the greatest value for communication and direction finding on its polar flight. Commander Gottwaldt, who was in charge of the radio and meteorological services on board, reported that communication with the outside world was maintained practically throughout the flight until, by an unfortunate mishap that could not have been foreseen, the 300 foot trailing aerial, covered with ice, was broken during the last stages of the voyage through the vessel having to fly extremely low. Even after this the *Norge* was able to locate her position by means of the radio direction finder, for which a separate aerial, bound to the fabric of the airship, was used.

Among Atlantic flyers with heavier-than-air machines, Commander Franco, who flew from Spain to South America in the spring of 1926, used a direction finder as well as an ordinary transmitter and receiver, to good effect. At the conclusion of that flight, Commander Franco and his navigator, Captain Ruiz de Alda, said: "We give full credit to the Marconi direction finder for route finding throughout the voyage."

Commander Byrd, after his flight, said: "Radio will play a great part in the future transatlantic navigation of the air. Science has not yet developed any instrument that will enable the air navigator to locate himself in a fog except by radio hearings. It seems that undoubtedly transatlantic landing fields of the future will have in the vicinity several radio direction finding stations, so that if the airplane arrives in foggy weather it will be able to locate itself by these radio bearings."

Perhaps, however, the most striking instance of the value of radio was its achievement during the wonderful flight of Captain Kingsfort-Smith and his companions in one of the greatest air adventures ever undertaken, the flight of the *Southern Cross* from California to Honolulu, from Honolulu to Suva, Fiji, and then to Australia. During their adventurous journey radio rendered great assistance to the navigators, and kept the world informed of every incident of the flight throughout the whole journey.

THE AIR PORT TRANSMITTERS

The four transmitters and antenna system are located 4½ miles from the flying field, leaving the field itself clear for taking off and landing. The antenna masts, placed at the corners of a 250-foot square, are 100 feet in height, and support four cage aerials of the inverted "L" type

RADIO IN THE FLYING ROUTINE

PERHAPS even more important, however, than these big examples of what radio has done for flying, is the day-to-day routine radio work carried out on the European air lines. Marconi AD6 equipment—a 150-watt telephone-telegraph set with a trailing aerial—is standard equipment on all Imperial Airways machines and on the machines of many other European air lines.

Every commercial airdome of importance in Europe is equipped with radio apparatus for communication and direction finding. At the London Air Port at Croydon the new radio station that has just been built replaces the one that has done duty there for the last seven years. The new station consists of a group of four 3-kw. transmitters, capable of telephonic and continuous wave and interrupted continuous wave telegraphic transmission, operated in conjunction with a radio direction finding receiver. This receiver has been specially designed for its work by the research department of the Marconi Company, and in addition to its remarkable selective characteristics it is arranged so that if required two or more circuits can be operated on different wavelengths for the reception of telephony and telegraphy on the same aerials.

Constant use is made of radio facilities by the pilots on the European air lines, and some of the leaders among them have said more than once that they would hesitate to fly an air liner not equipped with radio. On two or three occasions flights have been made between London and the Continent on foggy days when the pilots have not seen the ground from the time they took off to the time they landed. For instance, in November last Captain A. S. Wilcockson, an Imperial Airways pilot, flew a Handley-Page Rolls Royce plane from Paris to Croydon above a fog bank which obscured the ground practically the whole of the way. In spite of the denseness of the fog Captain Wilcockson completed his journey in 2 hours and 26 minutes, which was a good average time for the trip from Paris to London. When he started from Le Bourget at 8 A.M. visibility was about 1000 yards, and the weather report gave fog over most of the route except for patches of clear weather near the French coast. Five minutes after leaving Paris Captain Wilcockson found himself in dense fog and had to rise 2,000 feet to get above it. At this height the plane was flying in bright sunshine and continued to do so for the greater part of the journey. It was, however, necessary to fly entirely by compass bearing. The pilot asked for several bearings and positions from Croydon during the journey and these brought him in on a direct line to the Croydon Airdrome. There was one break in the fog, about 10 miles from Croydon, which enabled the pilot to recognize the ground and corroborate the fact that he was on the right bearing. The fog then closed in again and in his own words he "dropped right on to the airdrome."

THE CONTROL TOWER

The radio control room is located on the top floor of the tower of the Terminal Building at the Croydon Air Port. On the top of the tower are the directional antennas and a 100-foot horizontal antenna.

Captain Wilcockson said this was one of the worst fogs he had ever experienced but he had no doubt during the whole journey that he would get through in comfort, as his past experience with his radio apparatus had given him confidence that he could navigate on bearings through the fog, however dense it might be. "I had no difficulty at all in keeping in communication with Croydon at any time, whether I was in the fog, above it, or when coming down to the airdrome; but it would have been impossible to have made the journey without wireless," Captain Wilcockson said.

There were five passengers on the machine. They had a very happy and comfortable journey and were quite thrilled with their novel experience.

These are just a few of the things that radio has done and is still doing for flying.

Checking Up on Audio Distortion

By G. F. LAMPKIN

FREQUENCY distortion in audio amplifiers is primarily a question of poor design, and is somewhat beyond the province of the set builder. Amplitude distortion, on the other hand, is usually the result of improper operation; its detection, as Mr. Lampkin explains, may be accomplished by the use of a milliammeter, and its correction by the proper adjustment of the operating voltages of the amplifier. Any radio fan possessing a milliammeter can make the measurements described in this article, and in this way not only get better results from his amplifier, but also learn a great deal about audio amplification in general. —THE EDITOR.

OF THE two kinds of distortion that may occur in an audio-frequency amplifier, the one that usually receives the lesser attention is the one easier to correct. If an amplifier does not produce an output that is an exact, enlarged reproduction of the input—*i.e.*, if the output signals are not proportional in strength to the input signals at the broadcasting microphone, no matter how weak or strong those signals may be—obviously, distortion is taking place. Such action is designated as amplitude distortion; and the intelligent use of nothing more than a milliammeter will show the causes of this kind of distortion, when appropriate remedies may be applied.

The correction of the other kind of distortion—frequency distortion—necessitates the use of more extensive equipment. This type of distortion is characterized by unequal amplification in different parts of the frequency spectrum. It is the type that has received somewhat greater attention in the design of audio transformers, coupling impedances, etc., with good characteristics. Suffice it to say that, in the analysis of a receiver for frequency distortion, the frequency characteristic of a single coupling unit may mean little or nothing. The frequency characteristic of the loud speaker may mean much more than the characteristic of a single audio transformer, for example. Only the overall frequency characteristic of the receiver, from the antenna to the loud speaker, should be relied on as a figure of merit. It is impossible to make each unit of the receiver perfect; but, fortunately, it is not impossible to make the composite performance of all the receiver units approach perfection. Making one unit imperfect in the opposite sense to another will cause the defects to cancel, and so leave the near perfect characteristic. In any case, successful correction of frequency distortion requires the use of more than a milliammeter.

THE CAUSE OF AMPLITUDE DISTORTION

AMPLITUDE distortion is the result of amplifier overloading. A given tube is constructed to handle a certain amount of audio-frequency power without overloading. When this power limit is passed, overloading and amplitude distortion occur, so that the two go hand in hand. The more or less familiar curve that shows the relation between the plate current and the grid voltage of a vacuum tube can be used as a basis for showing how amplitude distortion takes place, and how it may be eliminated. Typical characteristic curves for one of the so-called power tubes are given in Fig. 1. They show how the plate current of the tube would vary when the grid voltage is swung through various values, for any particular B voltage. With a 135-volt B battery, if the C voltage is minus 30 volts, the plate current is 13 milliamperes; if minus 10 volts, 36 milliamperes, and so on. [Mr. Lampkin's curves are theoretical and must not be assumed to be those of a 112 or 171 type tube, whose characteristics might seem similar. They are the so-called "static" curves, and really for purposes of this argument should be "dynamic" instead. However, since the plate currents for these curves are so low, and because dynamic curves would differ for each load in the plate circuit—each transmitted audio frequency, for example, if the tube were working into a loud speaker—it has been thought much simpler to use static curves as shown. The argument would be the same in any case; overloading distortion could be predicted from inspection of dynamic curves, due to the fact that these curves are not exactly linear, although they are much straighter than the static curves shown.—THE EDITOR.] Suppose this tube were placed in an amplifier, with 90 volts on the plate and a C battery of 22 volts. The steady plate current would be 6.3 milliamperes, as indicated on the curve by the point "A."

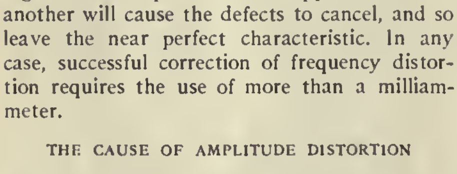


FIG. 1

The audio-frequency signal voltages, when impressed on the grid of the tube, would alternately add to and subtract from the bias voltage. In Fig. 2 the curve is redrawn for 90 volts B battery, and the point "A" is indicated. About this bias of 22 volts swings the audio voltage, alternately positive and negative, or to right and left, as shown along the extended vertical line. For each value of the resultant voltage on the grid, that is, the steady bias voltage plus or minus the instantaneous a.c. voltage, there is a corresponding instantaneous value of plate current. The curve drawn through the latter points, along the extended horizontal axis, is the form of the output current. So long as the signal voltages are comparatively low, say plus or minus four volts, the reading on the plate milliammeter will remain invariant. Although the plate current alternately increases and decreases, it must be remembered that the alternations take place one hundred or more times per second, and are much too fast for the ordinary milliammeter needle to follow. If the grid voltage does not swing beyond this plus or minus four volts the plate current on one half the cycle increases as much as it decreases on the next half cycle, so that the average force on the meter needle does not change and the reading stays constant. If a very low audio frequency were impressed on the grid of this tube, for example, a 10 cycle note, the milliammeter needle would actually wobble up and down from its average value, indicating that the instantaneous plate current varied in accordance with the incoming signals.

However, when a stronger signal comes through and forces the grid voltage to swing to wider limits, the reading on the milliammeter will change. This greater input voltage may swing from plus 16 volts to minus 16 volts, and would have a graphical representation as in Fig. 3. In this case, when the total grid voltage reaches minus 35 volts (that is, minus 22 due the C battery plus minus 13 due the signal), the plate current becomes zero, and remains zero as long as the voltage is more negative than this value. The curve of output current shows clearly the portion of the cycle during which the current is cut off. Such an output, for a strong signal, is decidedly not an exact, enlarged reproduction of the input. The graph of plate current shows that the positive halves of the wave are larger than the negative halves, for the latter have their tops chopped off. On the curve, the horizontal line at 6.3 milliamperes represents the plate-meter reading when no signal is impressed. On the strong signal the average value of the plate current jumps to 9.6 milliamperes, and this deflection is taken up by the meter. Thus the fluctuation of reading on the plate-current meter is coincidental with amplitude distortion, and may be used as an indication of the latter.

The remedy for distortion of this sort, where the meter deflects up on strong signals, is to decrease the C-battery voltage. The chopping off of the negative loops of plate current is due to the lower bend in the characteristic curve. Decreasing the C bias moves the working point away from this bend, that is, up the curve, so that the negative grid voltage swings cannot

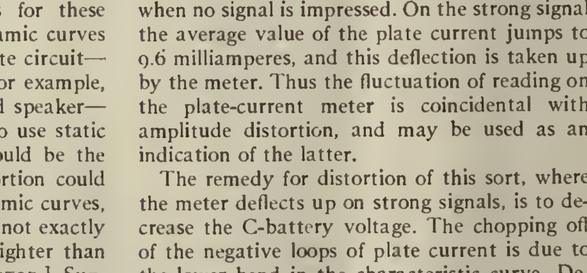


FIG. 2

reach it. This, of course, increases the steady plate current. Another remedy, and in this particular case a better one, is to increase the plate voltage to 135 or higher; it may be seen that this accomplishes the same purpose as above, by shifting the operating point to one of the higher curves and automatically increasing the distance to the lower bend of the curve.

DISTORTION FROM A POSITIVE GRID

AMPLITUDE distortion caused by cutting off of the positive peaks of signal voltage may be had at another portion of the curve—in particular, where the grid voltage crosses the zero line and goes positive with respect to the filament. To find out why this causes distortion requires that a start be made at the plate circuit of the preceding tube. The connections are those of Fig. 4A, which shows two tubes with resistance coupling. The coupling resistance, the coupling condenser, and the grid leak may be replaced by a single impedance, Z, equivalent in value; and the equivalent circuit is redrawn in Fig. 4B. The first tube has an alternating voltage generated in its plate circuit, due to the signal voltage at its grid. The generated voltage acts upon the internal plate resistance of the tube, R_p, and the coupling impedance in series, causing an alternating current to flow through them. Each element then has a voltage drop across it, the

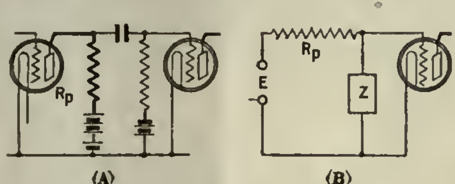


FIG. 4

sum of the drops being equal and opposite to the impressed voltage. The proportion of voltage that exists across Z may be expressed very nearly by $\frac{Z}{Z+R} \times$ total voltage.

That is, the larger the value of Z, the higher the voltage existing across it, and vice versa.

In the amplifier circuit, suppose the B voltage on the last tube to again be 90, but suppose the C bias has been dropped to only 9 volts, so that the operating point becomes "B" of Fig. 1. As long as the signal voltage swings within limits around "B"—namely, plus or minus 9 volts, there is no distortion. But if the signal amplitude runs higher, a direct current flows from filament to grid each time a signal peak makes the grid positive with respect to filament—exactly as a current flows to the plate when it has a positive voltage on it. When the grid is negative, no current flows to it, when positive, more or less current flows, depending on how far positive the voltage goes. This can only mean that the resistance from grid to filament has been decreased enough to permit current to flow; in fact, compared to the resistance when no current flows, the grid-filament resistance goes down tremendously when grid current flows. But the grid-filament path is in parallel with the coupling impedance; and when paths are in parallel, the equivalent impedance of the combination is always lower than that of the smallest element. Therefore, when the grid-filament path drops from a very high to a low value of resistance, it drags down the equivalent value of the coupling impedance, which in turn means that the a. c. voltage across the coupler decreases. It must be remembered that the grid-filament resistance is lowered only on the positive peaks, so it is at these points that the voltage is lost, and the tops of the input signal are cut off. Losing the tops of the wave means that the negative loops become relatively larger, so that the average of the plate current goes down. When amplitude distortion takes place because of the grid swinging positive, the reading on the plate milliammeter decreases. The remedy in this case is to increase the C-battery bias, moving the operating point away from the zero line so that the voltage swings cannot reach it.

THE PROPER REMEDY

IT MAY be seen, therefore, that there is an optimum value of C bias for each value of plate voltage. It is somewhat less than half of the bias necessary to give zero plate current, by inspection of the characteristic curves. The object is to the confine the grid voltage swings between the point of zero voltage and the lower point where the curve begins to bend—in other words, to the part of the characteristic where the "curve" is a straight line. If, after attaining the optimum bias, amplitude distortion still occurs, the remaining remedy is to increase the plate voltage; incidentally, this necessitates a new bias. The latter remedy is limited, of course, by the permissible plate voltage that may be applied to the tube. Above this power level, a new tube of higher power rating must be used; or, with the same tube, the condition simply means that the volume control on the receiver must be lowered, if amplitude distortion is to be done away with.

In the case where the grid voltage goes positive a meter may be placed in the grid circuit and used to show the grid current that flows. If the amplifier is resistance coupled to the previous tube, the flow of current will be so small as to be indistinguishable on a one-milliampere meter. The reason is that only a slight value of current flowing through the high-resistance grid leak provides a negative drop that compensates for the positive peak of signal, and the grid cannot go far enough past the deadline to give an appreciable current. Amplitude distortion is present, nevertheless, just as much as with any other coupling system.

Nothing has been said heretofore concerning filament saturation, but assumption has been tacitly made that in all cases the filament was capable of supplying all the electrons needed. If not, the characteristic curves shown in Fig. 1 would, at a given plate current, bend sharply to the right and continue horizontally. Such a curve would obviously cause serious amplitude distortion if the grid voltage variation came into the saturation region. The distortion would be analagous to that caused by grid current flow. Such distortion is often caused by an exhausted tube or a low voltage storage battery. Assurance must be had, then, that the filament of the tube is turned up to rated voltage, or that it has not lost its emission. A very approximate way of obtaining the optimum C bias is to short the grid to the filament of the amplifier tube, and read the plate current. Then remove the shorting wire and adjust the bias till the plate current is slightly more than half the former value. All makers of power tubes indicate the proper B and C voltage which should be used.

The effect of amplitude distortion is to introduce in the output frequencies that are not present in the input voltage. A pure, smooth input voltage, such as those of Fig. 2, impressed on an amplifier in which amplitude distortion occurs, would come out with one or both the peaks flat-topped, as has been seen. This sort of a wave is composed of more than is apparent from a casual inspection. It really has the original pure wave combined with a family of harmonics—waves

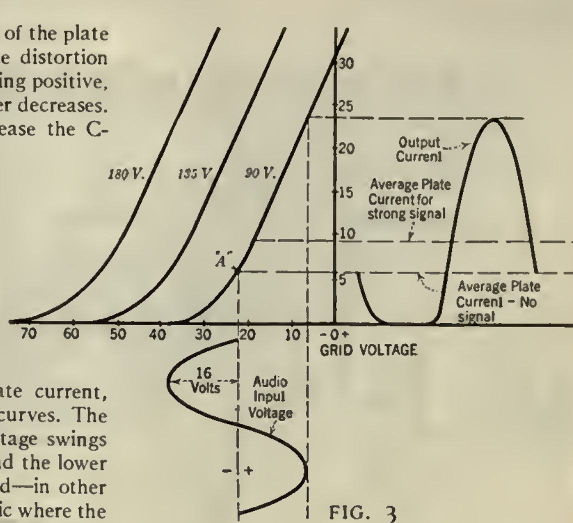


FIG. 3

with frequencies that are 2, 3, 4, 5, and so on, times the original frequency. For sake of illustration, suppose the signal has its positive peak cut off and that it is cut straight across. Such a wave is shown by the heavy curve of Fig. 5. The finer-lined curves show the components that are actually present, and which in the composite form the output wave. With this sort of action accompanying amplitude distortion, there is no wonder at the weird jumble issuing from some loud speakers when trying to reproduce musical selections, where each note proceeds from the loud speaker accompanied by its own little family of harmonics. A bit of experimenting with a milliammeter while listening to the reproduction will enable one to connect the results of amplitude distortion with the cause.

There is an interesting connection between frequency distortion and amplitude distortion. With transformers in the amplifier which will not pass the low notes, the set will handle a given power level without distortion. If, in an attempt to better the fidelity of reproduction, transformers be installed which will pass the low notes, the effective maximum power capacity of the amplifier will be lowered because, as is more or less well known, the lower notes contain more energy or have a greater amplitude. The better class of broadcasters have the low-frequency, large-amplitude voltages present in their output. Where the original amplifier would not pass these notes, the better transformers enable it to do so; and although the higher frequencies still come through with the same amplitude, the newly introduced low frequencies overload the amplifier. It is well to make sure that the loud speaker can reproduce the lower frequencies before installing transformers to pass them. Otherwise the only attainment would be to reduce the power capacity of the amplifier, for even though the speaker cannot respond to the new low notes, it will respond to their distortion products.

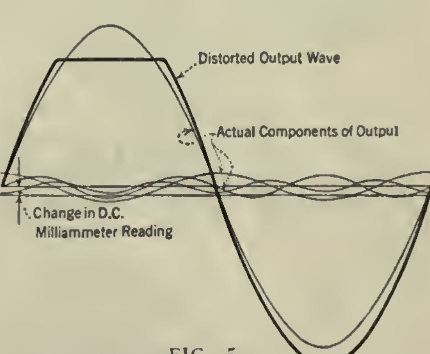


FIG. 5

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on this page. Order by number only.

1. Filament Control—Problems of filament supply, voltage regulation, and effect on various circuits. 1928 revised booklet, with circuit diagrams of popular kits. Radiall Company.
2. Hard Rubber Panels—Characteristics and properties of hard rubber as used in radio, with suggestions on how to "work" it. B. F. Goodrich Rubber Company.
5. Carborundum in Radio—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. The Carborundum Company.
9. Volume Control—A leaflet showing circuits for distortionless control of volume. Central Radio Laboratories.
10. Variable Resistance—As used in various circuits. Central Radio Laboratories.
12. Distortion and What Causes It—Hook-ups of resistance-coupled amplifiers with standard circuits. Allen-Bradley Company.
15. B-Eliminator and Power Amplifier—Instructions for assembly and operation using Raytheon tube. General Radio Company.
15a. B-Eliminator and Power Amplifier—Instructions for assembly and operation using an R. C. A. rectifier. General Radio Company.
17. Bakelite—A description of various uses of bakelite in radio, its manufacture, and its properties. Bakelite Corporation
22. A Primer of Electricity—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. National Carbon Company.
23. Automatic Relay Connections—A data sheet showing how a relay may be used to control A and B circuits. Yaxley Manufacturing Company.
26. Dry Cells for Transmitters—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. Burgess Battery Company.
30. Tube Characteristics—A data sheet giving constants of tubes. C. E. Manufacturing Company.
32. Meters for Radio—A catalogue of meters used in radio, with diagrams. Burton-Rogers Company.
33. Switchboard and Portable Meters—A hooklet giving dimensions, specifications, and shunts used with various meters. Burton-Rogers Company.
36. Charging A and B Batteries—Various ways of connecting up batteries for charging purposes. Westinghouse Union Battery Company.
37. Why Radio is Better with Battery Power—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. National Carbon Company.
46. Audio-Frequency Chokes—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. Samson Electric Company.
47. Radio-Frequency Chokes—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. Samson Electric Company.
48. Transformer and Impedance Data—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. Samson Electric Company.
49. Bypass Condensers—A description of the manufacture of bypass and filter condensers. Leslie F. Muter Company.
50. Audio Manual—Fifty questions which are often asked regarding audio amplification, and their answers. Amertran Sales Company, Incorporated.
52. Audio Quality—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. Silver-Marshall, Incorporated.
53. Tube Reactivator—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. The Sterling Manufacturing Company.
56. Variable Condensers—A bulletin giving an analysis of various condensers together with their characteristics. General Radio Company.
57. Filter Data—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. Electric Specialty Company.
58. How to Select a Receiver—A common-sense booklet describing what a radio set is, and what you should expect from it, in language that anyone can understand. Day-Fan Electric Company.
67. Weather for Radio—A very interesting hooklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. Taylor Instrument Companies.
69. Vacuum Tubes—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. Radio Corporation of America.
70. Improving the Audio Amplifier—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. American Transformer Company.
72. Plate Supply System—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. Amertran Sales Company.
73. Radio Simplified—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. Crosley Radio Corporation.
76. Radio Instruments—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. Jewell Electrical Instrument Company.
78. Electrical Troubles—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. Burton Rogers Company.
81. Better Tuning—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. Bremer-Tully Manufacturing Company.
83. Socket Power Device—A list of parts, diagrams, and templates for the construction and assembly of socket power devices. Jefferson Electric Manufacturing Company.
84. Five-Tube Equamatic—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. Karas Electric Company.
85. Filter—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. The Abox Company.
87. Tube Tester—A complete description of how to build and how to operate a tube tester. Burton-Rogers Company.
88. Super-Heterodyne Construction—A hooklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. The George W. Walker Company.
89. Short-Wave Transmitter—Data and blue prints are given on the construction of a short-wave transmitter, together with operating instructions, methods of keying, and other pertinent data. Radio Engineering Laboratories.
90. Impedance Amplification—The theory and practice of a special type of dual-impedance audio amplification are given. Alden Manufacturing Company.
92. Resistors for A. C. Operated Receivers—A booklet giving circuit suggestions for building a.c. operated receivers, together with a diagram of the circuit used with the new 400-milliampere rectifier tube. Carter Radio Company.
93. B-Socket Power—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. National Company, Incorporated.
95. Resistance Data—Successive bulletins regarding the use of resistors in various parts of the radio circuit. International Resistance Company.
96. Vacuum Tube Testing—A booklet giving pertinent data on how to test vacuum tubes with special reference to a tube testing unit. Jewell Electrical Instrument Company.
98. Copper Shielding—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. The Copper and Brass Research Association.
99. Radio Convenience Outlets—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set. Yaxley Manufacturing Company.

In sending the coupon below, make sure that your name and address are included and are plainly written. Also make sure that the listing of booklets from which you choose is that of the latest issue of the magazine, as Radio Broadcast cannot guarantee the delivery of booklets not listed in its current issue.

USE THIS BOOKLET COUPON

Radio Broadcast Service Department
Radio Broadcast, *Garden City, N. Y.*
Please send me (at no expense) the following hooklets indicated by numbers in the published list above:

. . . .

. . . .

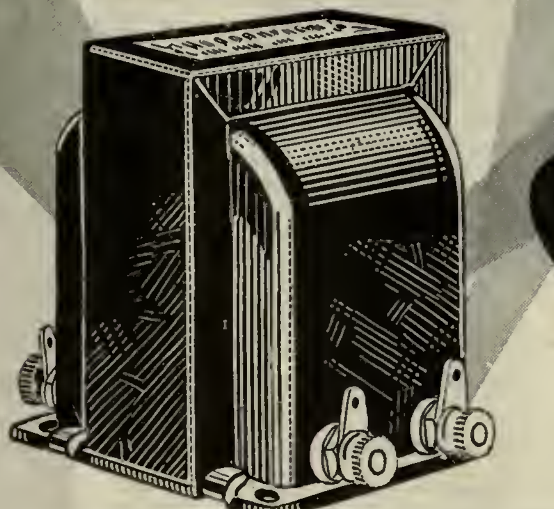
Name. . . . .
(Number) *(Street)*

Address. . . . .
(City) *(State)*

. . . .

ORDER BY NUMBER ONLY
This coupon must accompany every request. R B 8-28

101. Using Chokes—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. Samson Electric Company.
102. Radio Power Bulletins—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the BH or B rectifier tubes. Raytheon Manufacturing Company.
103. A. C. Tubes—The design and operating characteristics of a new a.c. tube. Five circuit diagrams show how to convert well-known circuits. Sovereign Electric & Manufacturing Company.
104. Oscillation Control with the "Phasatrol."—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. Electrad, Incorporated.
105. Coils—Excellent data on a radio-frequency coil with constructional information on six broadcast receivers, two short-wave receivers, and several transmitting circuits. Aero Products Company.
106. Audio Transformer—Data on a high-quality audio transformer with circuits for use. Also useful data on detector and amplifier tubes. Sangamo Electric Company.
108. Vacuum Tubes—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. Arcturus Radio Company.
110. Receiver Construction—Circuit diagram and constructional information for building a five-tube set using restricted field coils. Bodine Electric Company.
111. Storage Battery Care—Booklet describing the care and operation of the storage battery in the home. Marko Storage Battery Company.
112. Heavy-Duty Resistors—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. Ward Leonard Electric Company.
113. Cone Loud Speakers—Technical and practical information on electro-dynamic and permanent magnet type cone loud speakers. The Magnavox Company.
114. Tube Adapters—Concise information concerning simplified methods of including various power tubes in existing receivers. Alden Manufacturing Company.
115. What Set Shall I Build?—Descriptive matter, with illustrations, of fourteen popular receivers for the home constructor. Herbert H. Frost, Incorporated.
116. Using a B Power Unit—A comprehensive booklet detailing the use of a B power unit. Tables of voltages—both B and C—are shown. There is a chapter on trouble-shooting. Modern Electric Mfg. Co.
118. Radio Instruments, Circular "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. Weston Electrical Instrument Corporation.
120. The Research Worker—A monthly bulletin of interest to the home constructor. A typical feature article describes the construction of a special audio amplifier—Aerovox Wireless Corporation.
121. Filter Condensers—Some practical points on the manufacture and use of filter condensers. The difference between inductive and non-inductive condensers. Polymet Mfg. Corp.
122. Radio Tubes—Specifications and operating characteristics of vacuum tubes. Twenty-four pages. E. T. Cunningham, Inc.
123. B Supply Devices—Circuit diagrams, characteristics, and list of parts for nationally known power supply units. Electrad, Inc.
124. Power Amplifier and B Supply—A booklet giving several circuit arrangements and constructional information and a combined B supply and push-pull audio amplifier, the latter using 210 type tubes. Thordarson Electric Mfg. Co.
125. A. C. Tube Operation—A small but complete booklet describing a method of filament supply for a.c. tubes Thordarson Electric Mfg. Co.
126. Micrometric Resistance—How to use resistances for: Sensitivity control; oscillation control; volume control; regeneration control; tone control; detector plate voltage control; resistance and impedance coupling; loud speaker control, etc. Clarostat Mfg. Co.
127. Vitrohm News—A monthly bulletin dealing with the resistance problems of the home constructor and experimenter. Ward Leonard Electric Co.
128. Sangamo Condensers—A helpful table for converting capacities from microfarads to micromicrofarads. Sangamo Electric Co.
129. Tone—Some model audio hook-ups, with an explanation of the proper use of transformers and chokes. Sangamo Electric Co.
130. Screen-Grid Audio Amplification—Diagrams and constructional details for remodeling old audio amplifiers for operation with screen-grid tubes. Thordarson Electric Mfg. Co.
131. The Mershon Condenser—Two illustrated booklets giving the theory and uses of the electrolytic condenser. Amrad Corporation.
132. The National Screen Grid Short-Wave Receiver—Constructional and operating data, with diagrams and photographs. James Millen.
133. The National Shield-Grid Five—A circuit diagram with constructional and operating notes on this receiver. James Millen
134. Remler Service Bulletins—A regular service for the professional set builder, giving constructional data, blueprints, and hints on marketing. Gray & Danielson Mfg. Co.
135. The Radiobuilder—A periodic bulletin giving advance information, constructional and operating data on S-M products. Silver-Marshall, Inc.
136. Silver Marshall Data Sheets—These data sheets cover all problems of construction and operation on Silver-Marshall products. Silver-Marshall, Inc.
139. Power Unit Design—Periodical data sheets on power unit problems, design, and construction. Raytheon Mfg. Co.



THORDARSON R-300 AUDIO TRANSFORMER

SUPREME in musical performance, the new Thordarson R-300 Audio Transformer brings a greater realism to radio reproduction. Introducing a new core material, "DX-Metal" (a product of the Thordarson Laboratory), the amplification range has been extended still further into the lower register, so that even the deepest tones now may be reproduced with amazing fidelity.

The amplification curve of this transformer is practically a straight line from 30 cycles to 8,000 cycles. A high frequency cut-off is provided at 8,000 cycles to confine the amplification to useful frequencies only, and to eliminate undesirable scratch that may reach the audio transformer.

When you hear the R-300 you will appreciate the popularity of Thordarson transformers among the leading receiving set manufacturers. The R-300 retails for $8.00.

Power Supply Transformers

These transformers supply full wave rectifiers using two UX-281 tubes, for power amplifiers using either 210 or 250 types power amplifying tubes as follows: T-2098 for two 210 power tubes, $20.00; T-2900 for single 250 power tube, $20.00; T-2950 for two 250 tubes, $29.50.

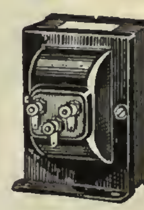
Double Choke Units

Consist of two 30 henry chokes in one case. T-2099 for use with power supply transformer T-2098, $14; T-3099 for use with transformer T-2900, $16; T-3100 for use with transformer T-2950, $18.

Power Compacts

A very efficient and compact form of power supply unit. Power transformer and filter chokes all in one case. Type R-171 for Raytheon rectifier and 171 type power tube, $15.00; Type R-210 for UX-281 rectifier and 210 power tube, $20.00; Type R-280 for UX-280 rectifier and 171 power tube, $17.00.

Speaker Coupling Transformers



A complete line of transformers to couple either single or push-pull 171, 210 or 250 power tubes into either high impedance or dynamic speakers. Prices from $6.00 to $12.00.

Screen Grid Audio Coupler

The Thordarson Z-Coupler T-2909 is a special impedance unit designed to couple a screen grid tube in the audio amplifier into a power tube. Produces excellent base note reproduction and amplification vastly in excess of ordinary systems. Price, $12.00.

THORDARSON ELECTRIC MANUFACTURING CO.
Transformer Specialists Since 1895
WORLD'S OLDEST AND LARGEST EXCLUSIVE TRANSFORMER MAKERS
Huron and Kingsbury Streets — Chicago, Ill. U.S.A.

THORDARSON ELECTRIC MFG. CO.
500 W. Huron St., Chicago, Ill. 3583-J

Gentlemen: Please send me your constructional booklets on your power amplifiers. I am especially interested in amplifiers using........................tubes.

Name..

Street and No...

Town...*State*......................

The *Radio Broadcast* LABORATORY INFORMATION SHEETS

THE RADIO BROADCAST Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4" x 6" filing cards, or in a notebook. The cards should be arranged in numerical order. In July, 1927, an index to all sheets appearing up to that time was printed. In the May, 1928, issue we printed an index covering the sheets published from August, 1927, to May, 1928, inclusive.

All of the 1926 issues of RADIO BROADCAST are out of print. A complete set of sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for \$1.00. Orders for the next set following can also be sent. Some readers have asked what provision is made to rectify possible errors in these sheets. In the unfortunate event that any serious errors do occur, a new Laboratory Sheet with the old number will appear.

—THE EDITOR.

No. 217 RADIO BROADCAST Laboratory Information Sheet September, 1928

Using a Milliammeter as a Voltmeter

WHAT RESISTANCES MUST BE USED

BY CONNECTING accurate fixed resistances in series with milliammeters it is possible to make very useful voltmeters that may be used to read filament voltages, plate voltages, C voltages, the output voltage of B-power units, etc. The accuracy of such a home-made voltmeter depends upon the accuracy of the milliammeter and the fixed resistance. Resistors accurate to within a few per cent. can be obtained by purchasing them directly from any reputable manufacturer.

The table on this sheet gives the values of resistances required with different milliammeters to read voltages from 1 volt up to 1000 volts. For example, if a 5-mA meter is to be used to read voltages up to 50 volts then a 10,000-ohm resistor is necessary. A 1.0-mA meter may be used to read voltages up to 1000 volts if a resistor with a value of 1,000,000 ohms (1 megohm) is placed in series with it. The values of resistance required to read voltages not given in the table, or for use with meters with higher ranges may be determined by dividing the voltage to be measured by the maximum current in amperes of the meter. Suppose that a 50-mA meter is to be used to read voltages up to 300 volts. Three hundred volts divided by 0.050 amperes (50 mA) gives 6000 ohms as the required value of the resistance.

Resistors with a wattage rating of 1.0 watt will be satisfactory for all those values given in the table, but it is advisable to use resistors with a rating of about 5.0 watts so that there will be little possibility of the value of the resistance changing due to heating. Also resistors with a rating of 5 watts, operating at considerably below their rated dissipation, will be likely to hold their calibration a much longer time than resistors of lower wattage.

VOLTAGE MULTIPLIER FOR MILLIAMMETERS

Milli-Amperes	1,000 Ohms	10,000 Ohms	100,000 Ohms	1,000,000 Ohms
1.	1. volt	10 volts	100 volts	1000 volts
1.5	1.5 "	15 "	150 "	
2.	2. "	20 "	200 "	
3.	3. "	30 "	300 "	
5.	5. "	50 "		
8.	8. "			
10.	10. "			

No. 218 RADIO BROADCAST Laboratory Information Sheet September, 1928

Servicing Radio Receivers

HOW FAULTS SHOULD BE LOCATED

THE tracing of faults in a radio receiver is not always an easy matter. There is a tendency to delve at random into the vitals of the receiver rather than to follow a systematic procedure by which the fault may generally be more quickly and easily located. In locating and remedying faults the systematic testing of the circuit and the apparatus in the receiver is essential.

Measuring instruments are frequently helpful in making these tests but a great deal may be done with a simple and inexpensive device. In the testing of the component parts in a receiver a pair of telephones connected in series with a small battery is useful in determining where the fault exists. The windings of a transformer may be readily tested by means of this simple circuit. When the two terminals are connected across the transformer winding a click will be heard if the circuit is continuous. Fixed condensers may also be tested, and here a click should be heard when the leads are placed across the terminals of the condenser, but no click will be heard when the terminals are removed unless the condenser is defective. If the insulation in the condenser is poor, however, or the condenser is definitely short-circuited, a click will be heard both when the circuit is closed and when it is opened.

Ordinary radio-frequency transformers and superheterodyne intermediate-frequency transformers, audio-frequency or radio-frequency choke coils, etc. may also be tested for continuity by connecting the test terminals across the terminal of the device under test. If the device being tested has a high resistance the click will be of less intensity than that obtained when testing a low resistance device. In any case, no click at all will indicate an open circuit.

When a radio receiver fails to operate, such tests as we have outlined here can be applied to the various components of the receiver to determine whether or not a piece of apparatus is at fault.

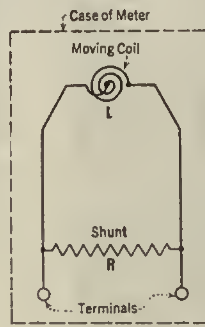
No. 222 Radio Broadcast Laboratory Information Sheet September, 1928

Measuring Instruments

THE AMMETER

LABORATORY Sheet No. 214 in the August issue explained the operation of a simple measuring instrument. An instrument of the type illustrated in that sheet can only be constructed to handle small currents, for to handle large currents the moving coil, L, and the leads to it would have to be made of very heavy wire. Since the coil, L, is part of the moving element, it must be kept light in weight; it is possible, therefore, to use only a fine wire on the coil. For larger currents the arrangement indicated in the sketch on this sheet is used. R is a resistor called a "shunt" consisting of one or more strips of a special alloy. The current in the circuit divides, most of it going through the shunt because its resistance is small in comparison with that of the moving coil of the meter. The current through the coil, however, is a certain definite fraction of the total current and therefore if we know the current flowing through the coil we can readily determine what the total current in the circuit is.

As an example, if the resistance of the shunt, R, is 0.01 ohms and that of the moving coil of the meter 0.99 ohms then the current divides in the same ratio. Out of every unit of current flowing through the circuit into which the meter is connected 99 parts flow through the shunt and one part flows through the meter. The current in the meter is therefore an accurate measure of the total current in the circuit and therefore for any one shunt the scale on the meter is calibrated to read directly the total current.



Meters with current ranges up to 50 or 75 amperes may be obtained with the shunt built inside of the case. For higher ratings the shunt forms an extra piece of apparatus and the meter is connected across it by means of a pair of wires.

No. 223 Radio Broadcast Laboratory Information Sheet September, 1928

Radio Transmission

HOW DISTANCE AFFECTS THE SIGNAL

PROBLEM: A receiver is tuned to a broadcast station located a certain distance away and signals from it produce sufficient power in the loud speaker circuit to make reception satisfactory. By what percentage will the power in the loud speaker be reduced if the receiver is removed to a point twice as far away from the transmitter, assuming, of course, that the sensitivity of the receiver remains unchanged.

Solution: To solve this problem we must know how the output power of a receiver varies with the r.f. input at the antenna and we must know how the received energy varies with the distance between the receiver and the transmitter.

(a) The power in the plate circuit of the power tube (and therefore the power supplied to the loudspeaker) varies as the square of the signal voltage on the grid of the power tube.

(b) The voltage output of a detector tube varies as the square of the voltage on its grid.

(c) Therefore, the power into the loudspeaker varies as the fourth power of the voltage impressed on the grid of the detector tube.

(d) The voltage impressed on the detector tube is proportional to the voltage at the antenna. Therefore the power into the loud speaker varies as the fourth power of the voltage impressed in the antenna.

(e) The voltage at the antenna varies as the field strength.

(f) Therefore, the power into the loud speaker varies as the fourth power of the field strength.

Statement (f) tells us how the power into the loud speaker varies with field strength. But the field strength surrounding an antenna varies inversely as the square of the distance between the transmitter and the receiver. Therefore, the power into the loud speaker varies inversely as the eighth power of the distance between the transmitter and the receiver.

The problem states that the distance between the receiver and the transmitter has been doubled, i.e. the distance has been multiplied by 2. The eighth power of 2 is 256; therefore by doubling the distance between the receiver and the transmitter we have cut down the power in the loud speaker to 1/256 of what it had been.

No. 224 Radio Broadcast Laboratory Information Sheet September, 1928

Text Books on Radio

THERE are certain books and radio magazines that the serious radio experimenter should not be without and in this sheet we give a list of some of what we consider the more important of the publications. The short descriptive sentence following each title will help to classify the book in our readers' mind.

Radio Instruments and Measurements. A 345-page book, presenting information regarding the more important instruments and measurements actually used in radio work. The contents is of interest to all radio engineers. The book is published by the Department of Commerce and is known as Circular No. 74. Obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., for sixty cents.

Principles Underlying Radio Communication. Another government publication to be recommended. This book is quite an excellent elementary text book of radio and general electricity and may be easily understood by anyone with a fair knowledge of algebra. Everyone should have it. It is known as Radio Communication Pamphlet No. 40, and the Superintendent of Documents, Government Printing Office, sells it for $1.00.

Principles of Radio Communication, by J. H. Morecroft. This is probably the most complete book on radio engineering. The text deals with all phases of the art of radio communication and the treatment is very complete, the book containing about 1000 pages. Published by John Wiley and Sons, Inc., New York City. Price: $7.50.

Thermionic Vacuum Tube, by H. F. Van Der Bijl. An excellent book setting forth the principles of operation of vacuum tubes. It is a very useful book for any radio engineer. Published by the McGraw-Hill Book Co., Inc., New York City. Price: $3.00.

Radio Engineering Principles, by Lauer and Brown. A book less extensive than Morecroft's but excellent for those whose requirements are satisfied with a shorter and less expensive text. It is a very scholarly presentation. Published by McGraw-Hill Book Co., Inc., New York City. Price: $3.50.

Radio Frequency Measurements, by E. B. Moullin. A book dealing with the theory and practice of radio measurements. A handbook for the laboratory and a text book for advanced students. Many of the measurements are made with the aid of the vacuum tube voltmeter. Published in England but it can be obtained from the J. B. Lippincott Co., in Philadelphia.

Practical Radio Construction and Repairing, by Moyer and Wostrel. This book aims to be of service to the amateur constructor and radio service man. It is essentially practical in its treatment. Published by McGraw-Hill Book Co., Inc., New York City. Price: $1.75.

Take the Advice of Leading Radio Service Organizations

...*Play Safe with*

PARVOLTS!

IF you want the real truth about condensers go to an organization that builds, services and repairs every type of radio receiver and power supply unit.

Such an organization is Rossiter, Tyler & McDonell. These engineers have had actual experience in every branch of radio. Mr. Frank McDonell says:

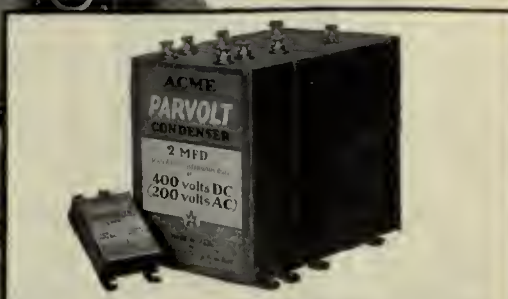
"We think so well of ACME PARVOLT *Condensers that we have samples constantly on display for all clients to see. Those of our customers who know radio also know that* PARVOLTS *are thoroughly reliable. We like our clients to realize that we use the best in radio."*

Mr. McDonell says that his firm has used many ACME PARVOLTS in both experimental and practical work and has never known one to break down under proper load. Absolute safety is vital with a firm doing a large volume of service work.

Should a condenser blow out, many dollars would be lost in ruined tubes, transformers, chokes and other parts. The experience of the nationally known house of Rossiter, Tyler & McDonell should be a good guide for other builders and service men to follow. Don't take chances with condenser break down. Play safe with ACME PARVOLTS.

Made by THE ACME WIRE CO., New Haven, Conn., manufacturers of magnet and enameled wire, varnished insulations, coil windings, insulated tubing and radio cables.

Mr. McDonell says: "Our PARVOLT *display board is very useful, for we frequently have occasion to show our clients how these condensers are made."*



ACME PARVOLT FILTER CONDENSERS—*Supplied in all standard mfd. capacities for 200, 400, 600, 800, 1000, and 1500 Volt D. C. requirements. Uniform height and width for easy stacking. Supplied singly or in complete housed blocks for the important power supply units such as Thordarson, Samson, and others.*

ACME PARVOLT BY-PASS CONDENSERS *are supplied in all standard mfd. capacities and for all required working voltages.*

ACME PARVOLT CONDENSERS

Made by the Manufacturers of

ACME CELATSITE HOOK-UP WIRE

ENAMELED AERIAL WIRE
Enameled copper wire in both stranded and solid types. Also Acme Lead-ins, Battery Cables, Indoor and Loop Aerial Wire.

CELATSITE FLEXIBLE and SOLID
For all types of radio wiring. High insulation value; non-inflammable. 10 colors.

ACME SPAGHETTI
A superior cambric tubing for all practical radio and other electrical requirements. Supplied in 10 colors.

No. 219 RADIO BROADCAST Laboratory Information Sheet September, 1928

Sizes of Tap and Clearance Drills

TABLE OF SIZES

THE table on this sheet will be found useful in constructing radio receivers and power units, when it is necessary to tap or drill holes to take a certain size machine screw. The first and second columns, headed "Screw Number" and "Threads per Inch" in each section of the table, identify the machine screw, and the third column headed "For Tap" gives the drill size if the hole is to be tapped so that the screw will thread into the hole. If the hole is to be drilled so that the machine screw passes through the hole, then the "Clearance" size drill should be used.

SCREW NUMBER	*THREADS PER INCH*	*DRILL NUMBER*		*SCREW NUMBER*	*THREADS PER INCH*	*DRILL NUMBER*	
		For Tap	*Clearance*			*For Tap*	*Clearance*
3	48	45	38	7	30	31	21
3	56	44	38	7	32	30	21
4	32	43	31	8	24, 30	30	17
4	36	42	31	8	32	29	17
4	40	41	31	9	24	29	13
5	30, 32	40	29	9	28	28	13
5	36	38	29	9	30	27	13
5	40	37	29	9	32	25	13
6	30, 32	35	26	10	24	25	8
6	36	33	26	10	30	22	8
6	40	32	26	10	32	21	8

No. 220 RADIO BROADCAST Laboratory Information Sheet September, 1928

The Roberts Four-Tube A. C. Receiver

PARTS REQUIRED

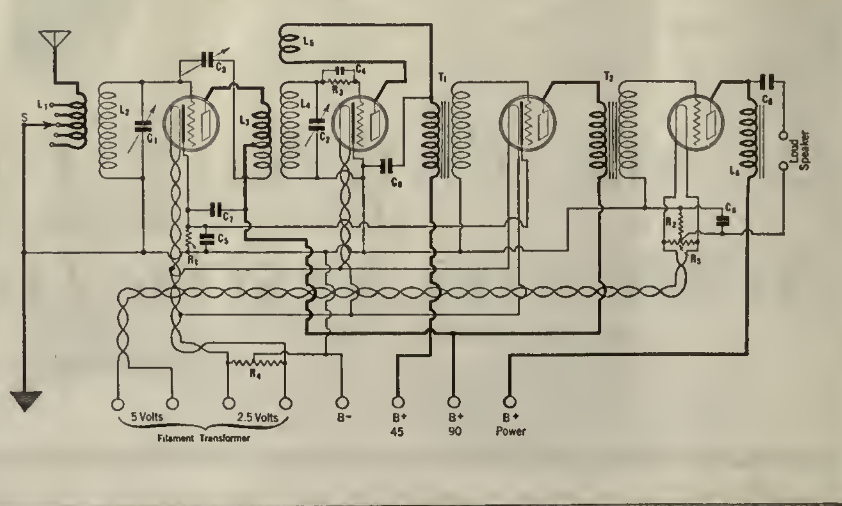
ON LABORATORY SHEET NO. 221 is published a circuit diagram that has been requested by many readers in their letters to the Technical Information Service. It is the circuit diagram of a 4-tube Roberts receiver for a.c. operation using three 227 type a.c. tubes and one 171A type tube.

The following parts are required for the construction of the receiver:

- C_1, C_2—2 Tuning condensers of a size such as to cover the broadcast band with the coils used. Homemade coils made according to the specifications given below require 0.0005-mfd. condensers
- C_3—Neutralizing condenser, 0.00002 mfd. maximum capacity.
- C_4—Grid condenser, 0.00025 mfd.
- C_5, C_6, C_7—3 Bypass condensers, 1.0 mfd.
- C_8—Output condenser, 2 to 4 mfd.
- C_9—Bypass condenser 0.0002 mfd.
- L_1, L_2—2 Thirteen point spider-web coils. L_1 consists of 35 turns of No. 22 d.c.c. wire tapped at every five turns. L_2 consists of 44 turns of the same size wire.
- L_3, L_4, L_5—3 Thirteen point spider-web coils. L_3 is a double wound primary consisting of two parallel windings of 18 turns of No. 26 d.c.c. L_4 is the same as L_2. L_5 consists of 12 turns of No. 22 d.c.c. mounted on a form so that its coupling to L_4 may be varied.
- L_6—Output choke coil, 30 henries.
- R_1—C bias resistor, 500 ohms.
- R_2—C bias resistor, 2000 ohms.
- R_3—Grid leak, 2 megohms.
- R_4, R_5—2 filament resistors, 20 ohms, center-tapped.
- S—Antenna tap switch.
- T_1, T_2—2 audio transformers.
- 3 five-prong sockets.
- 1 four-prong socket.
- Filament transformer supplying 2.5 and 5.0 volts.

No. 221 RADIO BROADCAST Laboratory Information Sheet September, 1928

Circuit of the Roberts Four-Tube A.C. Receiver



"Radio Broadcast's" Directory of Vacuum Tubes

THE table below is as complete as is possible to make it and should be a constantly useful reference for all radio workers. The data on some Western Electric tubes are included because some of our readers live in Canada and in other countries where tubes of this manufacture are available. We have followed the RCA-Cunningham tube terminology; other manufacturers make types of tube similar in each class, although each manufacturer has his own terminology. The reader who desires to use a CeCo tube for example, need only ask his dealer or the manufacturer for a CeCo of the 201-A type, etc. The same follows naturally for any of the vacuum tubes in the classifications below made by Arcturus, Sovereign, Sylvania, Marathon, Gold Seal, Sonatron, Kellogg, Magnetron, Speed, and others.

AVERAGE CHARACTERISTICS OF RADIO VACUUM TUBES

	GENERAL							DETECTION				AMPLIFICATION						
	MODEL	USE	CIRCUIT REQUIREMENTS	INTER-ELECTRODE CAPACITIES IN MMFD. FILAMENT COLD	"A" SUPPLY	FILAMENT TERMINAL VOLTAGE	FILAMENT CURRENT (AMPERES)	DETECTOR GRID RETURN LEAD TO	GRID LEAK MEGOHMS	DETECTOR "B" BATTERY VOLTAGE	DETECTOR PLATE CURR'T (MILLIAMPERES)	AMPLIFIER "B" BATTERY VOLTAGE	AMPLIFIER "C" BATTERY VOLTAGE	AMPLIFIER PLATE CURRENT (MILLIAMPERES)	A.C. PLATE RESISTANCE (OHMS)	MUTUAL CONDUCTANCE MICROMHOS	VOLTAGE AMPLIFI'TON FACTOR	MAXIMUM UNDISTORTED OUTPUT (MILLIWATTS)
Detectors and Amplifiers	C-11 WD-11					Same as below, except for base, which is old UV type												
	CX-12 WX-12	Detector or Amplifier	Transformer Coupling	G-F 6; G-P 5.5; P-F 7.5	Dry Cell 1½ V. Storage 2 V	1.1	.25	+F	3 to 5	22½ to 45	1.5	90 135	4½ 10½	2.5 3.5	15,500 15,000	425 440	6.6 6.6	7 35
	CX-112 A UX-112 A	Detector or ↓ Amplifier	Transformer Coupling	G-F 9; G-P 11; P-F 7.5	Storage 6 V	5.0	.25	+F	3 to 5	45	1.5	90 135	4½ 9	5.5 7	5,300 5,000	1,500 1,600	8 8	30 120
	C-299 UV-199					Same as below, except for base, which is old UV type												
	CX-299 UX-199	Detector or Amplifier	Transformer Coupling	G-F 3.6; G-P 3.5; P-F 4.5	Dry Cell 4½ V. Storage 4 V.	3.0 3.3	.060 .063	+F	2 to 9	45	1	90	4½	2.5	15,500	425	6.6	7
	CX-300 A UX-200 A	Detector	Transf. or Resis. Coupling	G-F 3.4; G-P 8.8; P-F 1.5	Storage 6 V	5.0	.25	−F	2 to 3	45	1.5	Following UX-200 A characteristics apply only for Detector connection			30,000	666	20	—
	CX-301 A UX-201 A	Detector or Amplifier	Transformer Coupling	G-F 5.8; G-P 10.1; P-F 6.1	Storage 6 V	5.0	.25	+F	2 to 9	45	1.5	90 135	4½ 9	2.5 3	11,000 10,000	725 800	8 8	15 55
	CX-322 UX-222	Radio Freq. ↓ Amplifier	Special Shielding	G-P 0.025	Dry Cell 4½ V. Storage 4-6 V.	3.3	.132	—	—	—	—	135	1½ *	1.5	850,000	350	300 M	—
	CX-322 UX-222	Audio Freq. ↑ Amplifier	Resistance Coupling	—	Dry Cell 4½ V. Storage 4-6 V.	3.3	.132	—	—	—	—	180 §	1½ □	.3	150,000	400	60	—
	UX-226 CX-326	Amplifier A.C. Filament Type	Transformer Coupling	G-F 3.65; G-P 8.2; P-F 2.1	Transformer 1.5 V.	1.5	1.05	—	—	—	—	90 135 180	6 9 13½	3.5 6 7.5	9,400 7,400 7,000	875 1,100 1,170	8.2 8.2 8.2	20 70 160
	C-327 UY-227	Detector A.C. Heater Type	Transformer Coupling	G-F 3.6; G-P 3.7; P-F 2.75	Transformer 2.5 V.	2.5 H	1.75	K	2-9 ¼-1	45 90	2 7	Following UY-227 characteristics apply only for Detector connection			10,000 8,000	800 1,000	8 8	—
	CX-340 UX-240	Detector or Amplifier	Resistance Coupling	G-F 3.4; G-P 8.8; P-F 1.5	Storage 6 V.	5.0	.25	+F	2 to 5	135 § 180 §	0.3 0.4	135 § 180 §	1½ 3	.2 .2	150,000 150,000	200 200	30 30	—
Power Amplifiers	CX-112 A UX-112 A	↑ Power Amplifier	No L.S.C. Required	G-F 9; G-P 11; P-F 7.5	Storage 6 V. Transformer 5 V.	5.0	.25	—	—	—	—	135 157½	9 10½	7 9.5	5,000 4,700	1,600 1,700	8 8	120 195
	CX-220 UX-120	Power Amplifier	No L.S.C. Required	G-F 4.5; G-P 5.4; P-F 4.4	Dry Cell 4½ V. Storage 4 V.	3.0 3.3	.125 .132	—	—	—	—	135	22½	6.5	6,300	525	3.3	110
	CX-371 A UX-171 A	Power Amplifier	L.S.C. except at 90 V.	G-F 6.8; G-P 9.5; P-F 6.5	Storage 6 V Transformer 5 V.	5.0	.25	—	—	—	—	90 135 180	16½ 27 40½	10 16 20	2,500 2,200 2,000	1,200 1,360 1,500	3.0 3.0 3.0	130 330 700
	CX-310 UX-210	Power Amplifier	L.S.C.	G-F 7; G-P 8; P-F 7	Transformer 7.5 V.	7.5	1.25	—	—	—	—	250 300 350 400 425	18 22½ 27 31½ 35	10 13 16 18 18	6,000 5,600 5,150 5,000 5,000	1,330 1,450 1,550 1,600 1,600	8 8 8 8 8	340 600 925 1,325 1,540
	CX-350 UX-250	Power Amplifier	L.S.C.	G-P 8.7	Transformer 7.5 V.	7.5	1.25	—	—	—	—	250 300 350 400 450	45 54 63 70 84	28 35 45 55 55	2,100 2,000 1,900 1,800 1,800	1,800 1,900 2,000 2,100 2,100	3.8 3.8 3.8 3.8 3.8	900 1,500 2,350 3,250 4,650

AVERAGE CHARACTERISTICS OF WESTERN ELECTRIC TUBES

MODEL	USE	CIRCUIT REQUIREMENTS	INTER-ELECTRODE CAPACITIES IN MMFD. FILAMENT COLD	"A" SUPPLY	FILAMENT TERMINAL VOLTAGE	FILAMENT CURRENT (AMPERES)	DETECTOR GRID RETURN LEAD TO	GRID LEAK MEGOHMS	DETECTOR "B" BATTERY VOLTAGE	DETECTOR PLATE CURR'T (MILLIAMPERES)	AMPLIFIER "B" BATTERY VOLTAGE	AMPLIFIER "C" BATTERY VOLTAGE	AMPLIFIER PLATE CURRENT (MILLIAMPERES)	A.C. PLATE RESISTANCE (OHMS)	MUTUAL CONDUCTANCE MICROMHOS	VOLTAGE AMPLIFI'TON FACTOR	MAXIMUM UNDISTORTED OUTPUT (MILLIWATTS)
"N" 215-A	Detector or Amplifier	Transformer Coupling	G-F 4.4, G-P 6; P-F 3.8	—	1.0	0.25	+F	2-9	45	1.0	67	6.0	1.0	20,000	300	6	8
"V" 1020	Amplifier	Resis. or Impedance Coupling	—	—	2.0	0.97	—	—	—	—	130	1.5	0.75	60,000	500	30	4.2
"L" 216 A	Amplifier	Transformer Coupling	—	—	5-6	1.0	—	—	—	—	130	9.0	8.0	6,000	980	5.9	60
"O" 1040	Power Amplifier	Transformer or Imped. Coupling	G-F 8.2; G-P 5.46; P-F 8.0	—	4.5	1.0	—	—	—	—	130	22.5	20.0	2,200	1,100	2.4	145
"E" 205 D	Power Amplifier	Transformer or Imped. Coupling	—	—	4.5	1.6	—	—	—	—	350	22.5	33	3,500	2,000	7	890

SPECIAL PURPOSE TUBES

MODEL	USE	CIRCUIT REQUIREMENTS	BASE	MAXIMUM OVERALL HEIGHT	MAXIMUM OVERALL DIAMETER	PURPOSE	CHARACTERISTICS	
CX-380 UX-280	Full-Wave Rectifier	Full-Wave Circuit	Large Standard UX Base	5⅝"	2 3/16"	Rectification in Eliminators	Filament Terminal Voltage . . 5 Volts Filament Current . . . . . . 2 Amperes A.C. Plate Voltage . . . . . . 300 Volts (Max. per Plate) } R.M.S.	Max. D.C. Output Current (both Plates) . . . . . . 125 Milliamperes D.C. Output Voltage at Max. Current as applied to filter of typical rectifier circuit . . . . . . 260 Volts
CX-381 UX-281	Half-Wave Rectifier	Half or Full Wave Circuit	Large Standard UX Base	6¼"	2 7/16"	Rectification in Eliminators	Filament Terminal Voltage . . 7.5 Volts Filament Current . . . . . . 1.25 Amperes A.C. Plate Voltage . . . . . . 750 Volts (Maximum) } R.M.S.	Recommended / Maximum A.C. Plate Voltage . . . . . . 650 . . 750 Volts D.C. Output Current . . . . . . 65 . . 110 Milliamperes D.C. Output Voltage as applied to filter of typical rectifier circuit . . 620 . . 620 Volts
CX-374 UX-874	Voltage Regulator	Series Resistance	Large Standard UX Base	5⅝"	2 3/16"	Constant Voltage Device	Designed to keep output voltage of B Power Units constant when different values of "B" current are supplied	Operating Voltage . . . . . . 90 Volts D.C. Starting Voltage . . . . . . 125 Volts D.C. Operating Current . . . . 10-50 Milliamperes
C-376 UX-876	Current Regulator (Ballast Tube)	Transformer Primary of 65 Volts for use on 115 Volt Line	Standard Mogul Type Screw Base	8"	2 1/16"	Constant Current Device	Designed to insure constant input to power operated radio receivers despite fluctuations in line voltage	Operating Current . . . . . . 1.7 Amperes Mean Voltage Drop . . . . . . 50 Volts Permissible Variation . . . ±10 Volts
C-386 UX-886	Current Regulator (Ballast Tube)	Transformer Primary of 65 Volts for use on 115 Volt Line	Standard Mogul Type Screw Base	8"	2 1/16"	Constant Current Device	Designed to insure constant input to power operated radio receivers despite fluctuations in line voltage	Operating Current . . . . . . 2.05 Amperes Mean Voltage Drop . . . . . . 50 Volts Permissible Variation . . . . ±10 Volts
C-377	Protective Tube	—	Double △ Contact Bayonet Auto. Type	1 7/16"	2½"	Current Limiting Device	Used in "B" Battery circuits to prevent excessive current resulting from short-circuit which might damage tubes or wiring	Voltage Drop Across — Half Filament / Entire Filament 2.5 / 5 At 20 Milliamperes D.C. 45 / 90 At 90 Milliamperes D.C.

↑ (↓) Note other use of this Radiotron above (below)
* Inner Grid −1½ Volts; Outer Grid +45 Volts, 0.15 Milliamperes
□ Outer Grid −1½ Volts; Inner Grid +22½ Volts, 6 Milliamperes
§ Applied thru plate coupling resistance of 250,000 Ohms
△ Connection to shell of base for third terminal which is the lead to mid-point of filament

Note: All grid voltages are given with respect to cathode or negative filament terminal

Maximum values not to be exceeded

Except for half ampere filament, UX-112 and UX-171 characteristics are identical respectively to UX-112-A and UX-171-A.
K . . . . Cathode
H . . . . Heater Voltage
L.S.C. . . Loud Speaker Coupling, consisting of either Choke Coil and By-Pass Condenser or Output Transformer of 1:1 or step down ratio, recommended wherever plate current (D.C.) exceeds 10 milliamperes.
M . . . . With a screen-grid tube, on account of circuit limitations, the actual voltage amplification obtainable does not bear as high a relation to the voltage amplification factor as in the case of three element tubes.

On Land, Sea, or in the Air DURHAMS are Supreme!

—wherever the perfect operation of radio apparatus is of paramount commercial and governmental importance —in radio transmitting or receiving apparatus—in power amplification units—in the sensitive resistance-coupled amplifiers of the photo-electric cell circuit in Television apparatus—there you will find that experienced radio engineers use and endorse DURHAM Resistors, Powerohms and Grid Suppressors! Why? Because years of experiment have proved the indisputable value of the DURHAM Metallized principle. Because these resistances are calibrated accurately according to their stated ratings. Because they are available for every practical resistance purpose from 250 ohms to 100 Megohms and in power ratings. We will be glad to send you descriptive literature explaining the entire Durham line.

DURHAM
METALLIZED

RESISTORS & POWEROHMS

INTERNATIONAL RESISTANCE CO., 2006 Chestnut Street, Philadelphia, Pa.

Notes on the "Cornet" Receiver

By W. H. WENSTROM

Lieut. Signal Corps, U. S. A.

THE article on the "Cornet" multiwave receiver, which appeared in the June number of RADIO BROADCAST (pp. 77–79) has evoked a number of inquiries as to the operation and use of the set, especially in regard to the possibility of its employment as a portable receiver. The following notes have been prepared to answer these inquiries, and to give additional data to those who have built the set and wish to increase its flexibility and range as much as possible.

Portable use: This circuit is admirably adapted to portable use. While not as sensitive as some multitube arrangements, it is far simpler and more dependable. Dry cell tubes are recommended, and the construction should be made more compact and mechanically stronger. It is advisable to mount all parts on a heavy bakelite panel. A single wire antenna about 50 feet long, and made fast at the free end fairly high up on some convenient object, is probably best. Unless a good ground is available a counterpoise, or insulated wire laid along the ground under the antenna, should be used. Other things, such as the frame of an auto, may be used as a counterpoise.

Use of dry cell tubes: Down to and including the 40-meter band UV-199 or UX-199 tubes can be used without any circuit changes whatsoever. In the 20-meter band the 199 tube begins to be rather cranky as an oscillator. Some lines of attack on its unwillingness to oscillate are:

1. Adjust potentiometer
2. Pick best oscillator out of several tubes
3. Connect a small condenser of "neutro" type between plate and grid.
4. Increase tickler turns.

In general, the 199 tubes will be quite satisfactory, used with either adapters or 199 sockets. The overall gain is something like half that of storage battery tubes. Several 199's must be picked over to find a really good detector which, when found, will fall considerably below a Ceco H or UX-200A in sensitivity. A possible combination would be a Ceco H as detector and a 199 as audio amplifier.

Coil for 200–550 meter band: A standard Silver-Marshall type No. 111-A coil may be used. With this coil the circuit as shown in the diagram on page 78 of the June issue tunes up to about 400 meters. To cover the remainder of the band, a Sangamo 0.00015-mfd. fixed condenser is connected in parallel with the condenser marked C_1.

Book Reviews

DRAKE'S RADIO CYCLOPEDIA. By Harold P. Manly. Frederick J. Drake & Co., Chicago. Second Edition, 1928. Price: $6.00

IN THE field of radio reception this should be a useful book, but the title is misleading, for in spite of its 920 pages, 1000 illustrations, and 1500 subjects, it is not a radio encyclopedia. Such a work, in any complete and satisfactory form, still remains to be written.

"Drake's Radio Cyclopedia" is printed without page numbers, making it easy for the publishers to insert new material as it appears, somewhat at the expense of the reader who dislikes to turn pages unnecessarily. The material is arranged alphabetically; if, for example, you want to read up on "Leakage Flux," you go through the L's until you reach the desired

(Continued on page 304)

Book Reviews

(*Continued from page 302*)

phrase, whereupon you are referred to "Flux, Leakage," and have to repeat the same procedure in the F's before you get what you are after.

The book is intended to bridge the gap between the engineer and the "radio worker"—presumably someone who must utilize the knowledge of the engineer and must do it without the engineer's training and characteristic lingo. In the receiver field it accomplishes this feat as successfully as it can be done. Diagrams are used liberally. Although some of them are very elementary, their inclusion is justified, since the volume is intended to help people who need it precisely because their technical training is meagre. One diagram shows, in illustration of "Ampere-Turn" and "Ampere-Hour," an ammeter with the pointer indicating 1 on the scale, a clock with the sector between 1 and 2 shaded, and a coil connected in series with the ammeter with one turn and three turns to indicate one and three ampere-turns, respectively. In another place, radio tools, including scissors, round nose pliers, diagonal cutters, a panel hole cutter, and a counter-sink, are shown. While such radio tabloid stuff will not result in a tremendous demand for the book at M. I. T., it may help some of the lads struggling with definitions which seem obvious to a lot of people who once had to learn them just as painfully.

Although the subject matter is not confined to radio receivers, everything is considered from the standpoint of a radio worker whose experience has been confined to reception. The treatment of television is sketchy and inferior to what can be learned from some of the newspaper supplements nowadays. There is nothing of practical value to the radio telephone transmitter specialist, and very little of anything in that line. Under "Microphone" there are five lines of formal definition, with no description of different types or modes of operation. Four lines are devoted to "Radio Telephony." But in this edition 56 new pages have been added on the screen-grid tube and the practice of socket power receiver operation. This is a typical placing of emphasis in this volume.

The treatment is non-mathematical, as would be expected, and where algebraic formulas are used symbols are avoided, the words being written out.

In its class "Drake's Radio Cyclopedia" is a worthy job, except for the title. Either a few hundred pages on radio transmitter technique should be included in the next edition, or it should be called "Drake's Radio Receiving Encyclopedia."

BIBLE DRAMAS. By William Ford Manley. Fleming H. Revell Company, 1928.

THIS book presents in printed form the series of biblical dramas broadcast on Sunday nights through the N. B. C. system. The stories of James of Galilee, David and Goliath, Judith, and other notables of Scripture are told in the form of radio plays suitable for church and social gatherings. A few pages of "Production Suggestions" precede the actual stories. I was not particularly impressed by the literary form of those of the plays I heard on the air, but they read quite well and the style partakes somewhat of the majesty of the Biblical narratives which, whatever you may think of the content, are not bad epics. The book will naturally interest the older citizens in the villages more than the metropolitan flappers who are dutifully following the prediction of the Epistle of Jude, 18, "In the last time there shall be mockers, walking after their own ungodly lusts," but even this is not certain, with the "King of Kings," at this writing, showing once more on Broadway.

(*Continued on page 306*)

Book Reviews

(*Continued from page 304*)

THE ELEMENTS OF RADIO-COMMUNICATION. By O. F. Brown, with a Foreword by Admiral of the Fleet Sir Henry B. Jackson. Oxford University Press. New York, 1927. 216 pages. $3.50

IN HIS foreword Admiral Jackson recommends this text on radio communication to those who, like himself, have no mathematical abilities. It is not intended for radio specialists as much as for those outside the profession who wish to gain some knowledge of radio operations through the study of a moderately technical work. The danger in all such efforts is that the results will seem slight to the serious radio engineer, even when the text used may present grave difficulties to many of its students. Sir Henry thinks that Mr. Brown's book should appeal "to the public generally who wish to know how broadcasting works without having to study mathematical formulae." It seems to the reviewer that the book is too technical for this audience. Sir Henry's thirty-odd years in radio work lead him to minimize many difficulties which exist for people without his background.

Chapter 1 contains some historical treatment of the subject which, to critical American readers, will appear somewhat over-simplified, insular, and not inclined to give full credit to the work of German and American pioneers. The following chapters discuss such subjects as high-frequency alternating currents, transmission of damped and continuous waves, thermionic valves, radio telephony, and directional reception, with considerable clarity and about the same degree of detail with which a college text on physics tackles the problems of mechanics and optics. This entails some faults of omission, as in Chapter 8, where the author, after itemizing the defects of commercial carbon microphones, turns abruptly to condenser transmitters, apparently ignoring the existence of high quality carbon microphones.

In his chapter on "Short-Wave Transmission and Reception" Mr. Brown includes a graceful compliment to the amateurs, whose work he calls "extremely brilliant," and he goes on to say: "There is little doubt that the remarkable results of these men had in no small measure the effect of causing other experts to investigate and consider seriously the possibilities of short waves."

The last chapter, on the "Nature and Origin of Atmospherics," contains an interesting account of the research work of Watson Watt and E. V. Appleton and should be read by engineers interested in this special branch.

—CARL DREHER.

Something to Omit

IF I were a Radio Commissioner, which God forbid, the first stations which I should banish from the air are those which announce grandly at the beginning and end of each transmission period that they maintain their assigned frequency with a quartz crystal standard. That is as if you went to some Vice President and asked him to give you a job because you clean your teeth every morning with dental floss and come to the office without poisoning policemen's horses or assaulting shop girls. A radio station is bound by law to stay on its assigned frequency. How it does it is surely none of the public's concern. It can do it, for all the listeners care, by hanging a piano on the aerial or uttering prayers. The act requires no more mention than any other act of public decency. The listeners want entertainment; the correct functioning of the transmitter may be taken for granted. To argue otherwise indicates a strange misunderstanding of the normal proprieties.

—CARL DREHER.

A NEW SHORT WAVE ADAPTER

FEATURING EASY TUNING AND SUPER SENSITIVITY

RECORP LOWAVER

The perfected "High Frequency" Converter for use with your regular radio receiver—any make. Plugs in. No change in wiring. Change back instantly.

Hear around the world, telegraph, telephone, and television. Penetrates local electrical storms, day or night. Clear as crystal summer or winter.

Model DC for all sets using A and B batteries or eliminators, and Model AC for sets using the new AC tubes, 226 and 227.

This is a wonderful proposition for the technical dealer or professional custom builder. Sold completely assembled, unwired, nothing extra to buy, and with full directions. Price, two or more, $12.00. Sample, $13.00. Retails for $25.00.

Post paid in U. S. Canada and Foreign, 60c extra. Also sent C.O.D. upon receipt of $1.00 deposit. Cash, money, or certified check.

Literature upon request. Our dealers are our best reference.

RICHARDSON ELECTRIC CORPORATION

P. O. Box 2056 Fort Lauderdale, Fla.

NA-ALD

TRADE MARK

SILENCER SOCKET

No. 481-XS. 65c.

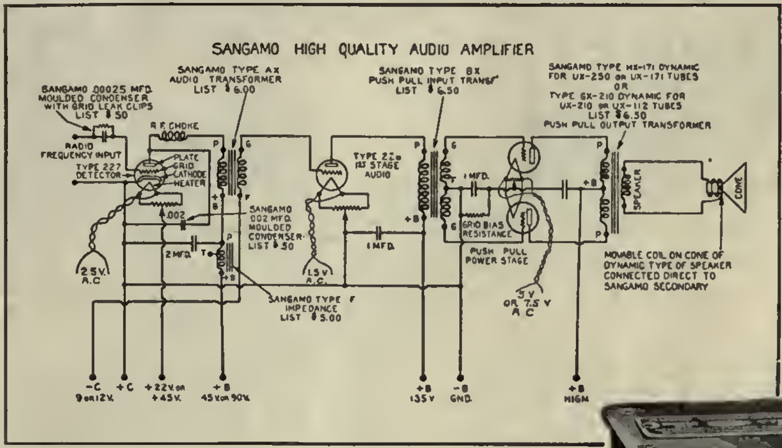
For anyone building short wave or regular sets, using sensitive detector or screen grid tubes, the Na-Ald 481-XS socket is recommended. This silencer socket prevents microphonic noises and preserves the life of these delicate tubes. Recommended in circuits elsewhere in this magazine.

Na-Ald makes a socket for every purpose, as well as more than thirty different adapters. Write for new catalog just off the press.

Alden Manufacturing Company

Brockton, Massachusetts

Build this Modern Amplifier!



gets the low notes

The up-to-date radio is using "push-pull" for the last audio stage with two power tubes—the output going directly to the moving coil of a dynamic speaker. Thus ample capacity and energy for those low notes are available. Such an amplifier using good transformers gives a quality of reception never attained before.

Little expense necessary

Sangamo, manufacturers of precision electrical apparatus since 1899, have recently completed a line of audio transformers and impedances which match the various types of power tubes now available—*and which sell at a price considerably lower than usual for apparatus of high quality.* Included in this new "X" line is the "AX" audio transformer which has an extremely flat amplification curve over the entire audio frequency band. Two of these transformers and a Sangamo Output Impedance to match the power tube used form the basis for a remarkably efficient amplifier of the conventional type.

Push-Pull Amplifiers

The circuit diagram shown above is the latest and perhaps most satisfactory amplifier developed to date. It will be noted that the Sangamo Output Transformer is especially designed for the particular power tube used and for a dynamic speaker. That is, the primary has an impedance to match the tube and secure maximum energy transfer and the secondary impedance matches that of the moving coil of the dynamic speaker. The Sangamo Input Transformer has an accurately divided secondary to secure practically identical frequency curve characteristics for both tubes in the stage. Similarly in the "X" line are found Push-Pull Transformers to match power tubes but designed for use with speakers not of the dynamic type.

The cost for the apparatus is shown in the diagram. The approximate cost of building the amplifier is only about $25.00.

Latest Audio Hook-ups

A free circular describing Sangamo apparatus and circuit diagrams of best types of audio amplifiers will be sent on request.

SANGAMO ELECTRIC COMPANY

Springfield, Illinois

Letters from Readers

Our Latest Departures

SEVERAL recent additions to the editorial contents of RADIO BROADCAST have brought forth comment from many sources. We are happy to feel that our innovations are worthy of response, and want to get as much of it as we can—both favorable and adverse. Here's some from Mr. Lewis S. Maxfield, of Brooklyn, N. Y.

To the Editor:

Allow me to express my appreciation for the series of articles entitled "Home Study Sheets" beginning on page 135 of the July issue. This is something that has been long wanted and I am pleased to see that my favorite magazine is to publish same.

Let us have more of the science and physics side of radio and less knocking of programs, which after all are free and if you don't like them don't listen.

Mr. Maxfield is an engineer and physicist. Here's what an amateur thinks—Sherwood J. Beutler, of Buffalo, N. Y. (8-HT)

To the Editor:

I wish to commend you upon the interesting technical articles you are publishing in RADIO BROADCAST, particularly your introduction of the "Home Study Sheets"; also the addition of Mr. Robert S. Kruse to your engineering staff.

I have been active in the amateur and laboratory development of radio for the past ten years, during which time I have reviewed many radio magazines, but for clear, reliable technical data I believe RADIO BROADCAST rates the highest of them all.

Unfortunately, we can't exactly claim Mr. Kruse as a member of our engineering staff, but there are a great many more articles that he is cooking up for future issues. Incidentally, some of the answers to the problems in the "Home Study Sheets" are making the Laboratory Staff sit up and take notice in regard to such details as neatness, clarity, and general excellence of arrangement.

Our Mistake

GLARING mistakes have occurred in every form of printed matter known, from the famous "Wicked Bible" to the modern tabloids. Here is one from the July issue of RADIO BROADCAST, in Mr. Messenger's article on the universal set tester. Among others, W. D. Wollaver, Watertown, N. Y. has written to us about it.

To the Editor:

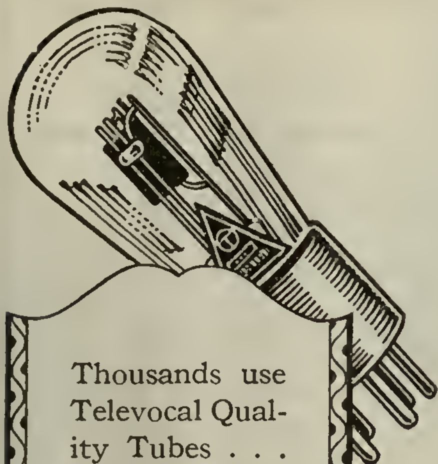
In your July issue [Page 149] you had an article on a three meter tester and gave a diagram of the same. I have started building the tester, but have run up against something which seems incorrect. The minus terminal of the socket has no connection in the diagram.

I have not tried to work the circuit on my own hook, as I thought there should be a connection on the terminal. I would greatly appreciate your help on this.

Mr. Messenger himself caught the error and telegraphed that the connection should go from the minus terminal on the tube socket to the minus lead from the plug on the cable.

The *American Mercury* recently offered a salary of a million dollars a year to an infallible proof reader. All the applicants for the job were refused, because in the very paragraph in which the offer was made there was a typographical error which none of the applicants caught. And it wasn't a trick! We are in the same boat with the *Mercury*. After checking, rechecking, and

(*Continued on page 310*)



Thousands use Televocal Quality Tubes . . . there must be a difference! All standard types. Ask for them at dealers.

Televocal Corporation
Televocal Building
Dept. B-2, 588 12th Street
West New York, N. J.

Televocal
Quality Tubes

RADIO DEALERS

Send for our catalog illustrating the products of over 100 radio manufacturers.

WHOLESALE ONLY!

F. D. PITTS COMPANY
219-223 Columbus Ave.
BOSTON, MASS., U. S. A.
Established 1919

Increased Amplification Improved Quality with this new valve

Full size illustration of the DA2 amplifying valve. Price $3.00 each.

Harold P. Donle's Latest Achievement

THE inventor of the famous Sodion Detector valve brings out this DA2 6-volt amplifying valve which can be used in any type D. C. set with no changes.

Amplification for both audio and radio frequency are greatly increased, and the quality of your set vastly improved.

Those that have tried these valves are enthusiastic about them.

Here is what some of them say:

"We seem to obtain far greater volume and clarity."

"Really, it is the most marvelous valve I have ever come in contact with."

"I have tried two of these tubes in my regular tuned radio frequency broadcast receiver, and I am delighted with the increase in volume and distance obtained."

"Received the four tubes ordered, to-day. Must say that they even exceed all my expectations."

"It is a pleasure to report that the three tubes I received from you Saturday have increased the sensitivity of my Hammarlund-Roberts Hi-Q to a considerable degree. I also tried one in the R. F. stage of a Browning-Drake and there too, the gain was considerable."

"Excellent for low wave sets"

If your dealer has not yet received his stock, mail orders will be promptly filled upon receipt of check.

The Donle Electrical Products Corporation
MERIDEN, CONNECTICUT

Letters from Readers

(*Continued from page 308*)

re-rechecking diagrams and copy, we can only make a prayer to the gods of radio and wait for the letters to come in.

As a Listener See It

THE editorial department, "The March of Radio," has never been guilty of "kid-glove" tactics in dealing with the politico-radio situation in these parts. Although this policy may have added a few sore heads to our list of readers, we feel that the vast majority agree with us that adverse criticisms in this department are made for the benefit of the broadcast listener. It is, therefore, particularly pleasing to quote a comment from a Southern reader on an editorial attack on a Southern broadcast station. The editorial deplored the fact that the only Southern station to ask for increased power was KWKH, which had in the past consistently ignored the orders of the Federal Commission and employed its facilities for the vilification of that body.

To the Editor:

I have had occasion heretofore to express my appreciation of your editorial policy and am writing again for that purpose.

Your comment in the June issue [Page 69] relative to conditions in the South and particularly your reference to station KWKH, Shreveport, has our hearty approval. In the July issue your frankness and fearlessness in stating the case against the Radio Commission deserve our best thanks.

These things, in a periodical of such high standing, and so completely expressive of radio listener sentiment, are bound to have their effect eventually.

E. W. MATTHEWS,
Augusta, Ga.


Advance Fireplace Co., Detroit

Decorative *and* Efficient Dynamics

Showing the fireplace and wall picture speakers.

HERE'S the newest thing in dynamic speakers—an attractive fireplace screen or handsome picture speaker — that you can easily build yourself. Either will be a worthwhile addition to your home, and you have a thoroughly dependable dynamic unit, the latest thing in radio, as well.

The fireplace baffle board comes in gum wood, walnut or mahogany, or unfinished for you to do in any color to match any decorative plan. It is sent knocked down and is easily assembled. When assembled it is 30 inches high and 36 inches wide.

The picture speaker comes in several beautifully oil painted designs on velvet or will be painted to your own design at no extra cost. Including frame the size is 24 x 34 inches. A six-inch magnetic speaking unit of standard make is used.

Enjoy your radio to the fullest this winter with these splendid and decorative speakers. We furnish everything. Write to-day for our remarkably low prices.

Color! Tone!

Everyone is using color in their homes now. With either our fireplace or picture speakers you can have color that will harmonize with your home color scheme.

And our speaking units will give you a richness, a clarity of tone you usually associate with speakers much higher in price. Get our prices today.

BRYDEN PRODUCTS, Inc.

2559 Bellevue Ave. Detroit, Mich.

RADIO BROADCAST

WILLIS KINGSLEY WING, Editor

OCTOBER, 1928

KEITH HENNEY
Director of the Laboratory

EDGAR H. FELIX
Contributing Editor

Vol. XIII. No. 6

CONTENTS

The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

AMONG OTHER THINGS. . .

READERS who did not see our announcement in this space last month with respect to the change in our publication date and who failed to see our October issue when they expected may be somewhat confused. Effective with this number, RADIO BROADCAST is on sale at all good newsstands on the first of the month. That is easy enough to remember.

THE issue before you now contains an unusually wide range of material, and in the descriptions of receivers offered the constructor in kit form for the present season, is especially complete. Our November issue promises a story on present trends in radio progress, a description of a new audio amplifier system, two articles on television, the first of a series of practical articles on radio service for men actually facing the music, and a variety of constructional articles. These are in addition to our popular departments which will run as usual.

A FEW of our readers who carefully classify the contents of each issue feel that each article should be classified according to the Dewey decimal system when published. At one time our excellent British contemporary, *Experimental Wireless*, classified their articles this way, but has since discontinued the practice. RADIO BROADCAST is quite willing to serve its readers, but we feel that this classification would appeal to all too few. The editor would be glad to hear from those who favor the scheme—and from those who prefer the *status quo*.

AND here we group many miscellaneous matters; read them, but remember, you were warned! . . . The complete set of "R. B. Lab. Data Sheets" in book form—No. 1-190—is now available at $1 per copy from the Circulation Department of this company. . . . We shall soon start a special department, along lines similar to "Our Readers Suggest—" to be made up of practical contributions from radio service men and professional set builders. Quite a few interesting contributions are already in the office and readers who desire to submit any ideas that seems to them worth while passing on are invited to do so. The same general rules hold for these contributions as for the "Readers Suggest" department. . . . How many readers are interested in the problems of series-filament connection for a.c. operation? We should like to hear from readers who have done some work along this line, or from those who would like an article devoted to the subject. . . . In the past few weeks, our mail has contained a number of simple questions about radio which we are thinking of answering in a short article composed simply of the questions and their answers. We invite the submission of short and particularly troublesome questions which readers would like to see treated in this way. . . . A radio house in Sao Paulo, Brazil, informs us that they are expanding and desire exclusive American agencies for radio apparatus in Brazil. Manufacturers who wish to get in touch with this house may write the editor. . . . Our request in the August "Strays" for methods of testing for hard and soft tubes has brought two answers. One may be found in this number on page 348, in the "Strays" department, and the other on page 364 in the department "Our Readers Suggest—"

TWO of the writers in this issue who have investigated the use of the screen-grid tube with various kinds of coils, arrive at conclusions which are different—but most interesting. The stories concerned are by Bert Smith and Glenn Browning.

—WILLIS KINGSLEY WING.

DOUBLEDAY, DORAN & COMPANY, INC., Garden City, New York

MAGAZINES

COUNTRY LIFE
WORLD'S WORK
THE AMERICAN HOME
RADIO BROADCAST
SHORT STORIES
EDUCATIONAL REVIEW
LE PETIT JOURNAL
EL ECO
FRONTIER STORIES
WEST
THE AMERICAN SKETCH

BOOK SHOPS (Books of all Publishers)

NEW YORK: LORD & TAYLOR; JAMES MCCREERY & COMPANY; PENNSYLVANIA TERMINAL AND 166 WEST 32ND ST.; 848 MADISON AVE. AND 51 EAST 44TH STREET; 420 AND 526 AND 819 LEXINGTON AVENUE; GRAND CENTRAL TERMINAL AND 38 WALL STREET
CHICAGO: 75 EAST ADAMS STREET
ST. LOUIS: 223 N. 8TH ST. AND 4914 MARYLAND AVE.
KANSAS CITY: 920 GRAND AVE. AND 206 WEST 47TH ST.
CLEVELAND: HIGBEE COMPANY
SPRINGFIELD, MASS.: MEEKINS, PACKARD & WHEAT

OFFICES

GARDEN CITY, N. Y.
NEW YORK: 244 MADISON AVENUE
BOSTON: PARK SQUARE BUILDING
CHICAGO: PEOPLES GAS BUILDING
SANTA BARBARA, CAL.
LONDON: WM. HEINEMANN, LTD.
TORONTO: DOUBLEDAY, DORAN & GUNDY, LTD.

OFFICERS

F. N. DOUBLEDAY, *Chairman of the Board*
NELSON DOUBLEDAY, *President*
GEORGE H. DORAN, *Vice-President*
S. A. EVERITT, *Vice-President*
RUSSELL DOUBLEDAY, *Secretary*
JOHN J. HESSIAN, *Treasurer*
LILLIAN A. COMSTOCK, *Ass't Secretary*
L. J. MCNAUGHTON, *Ass't Treasurer*

TERMS: $4.00 a year; single copies 35 cents.

Lowest Wholesale Prices

Set Builders

Set Builders and experimenters will welcome an association here where tremendous stocks of practically all of the nationally advertised lines are carried—coupled with an organization trained to serve. Immediate shipments are assured. Silver-Marshall—Hammarlund-Roberts—Aero—Tyrman and practically all of the latest kits and parts are available. Your orders, large or small, will be handled with a promptness and dispatch that should prove a revelation to you in Radio Service.

Dealers

Dealers who line up with Allied Service will never disappoint their trade on deliveries. Our immense stocks in Sets, Parts, Kits and Accessories enable you to render real service to your trade. Immediate shipments insure rapid turn-over—eliminating the necessity of carrying large stocks on hand—and this along with lowest market prices will prove an ideal connection for the live dealer.

Allied Radio Corporation is composed of a large corps of trained men who have had years and years of experience in radio. They know how to get results. Their great fund of experience is now available for your benefit. They know the newest improvements, the up-to-the-minute demands of the trade and are ready to give you personal, helpful service.

50,000 FEET OF RADIO

50,000 square feet of floor space in a large modern building is devoted exclusively to radio. Floor after floor is filled with a tremendous stock of every variety that is exceptionally complete in kits, parts and sets of every description, Here are found the latest improved designs and styles in radio equipment.

NEW A. C. SETS AND KITS

New A. C. sets priced as low as $35.45. Also a wonderful array of beautiful consoles ranging in price from as low as $12 up to $200. A complete assortment of the famous Silver-Marshall parts and kits—in stock ready for your call. Practically all of the nationally advertised lines in parts and kits are available here for immediate shipment. New A. C. Sets, Power Dynamic Speakers—all the latest and newest in Radio is here at prices that actually defy competition.

LOWEST WHOLESALE PRICES

Tremendous sales volume coupled with a rapid turnover to the thousands of radio dealers throughout the country who have come to depend on Allied Service enables us to go into the open market and buy for cash—at tremendous savings—and these savings are passed right on to you in the way of better merchandise and lower prices.

IMMEDIATE SHIPMENTS

The Allied organization is trained to service. Real team work from executives and department managers to stock clerks and office boys—all animated by a desire to serve—to make Allied service Radio's most dependable service.

Send for Large, Free, New, Illustrated Catalog "A-1"

Allied Radio CORPORATION

Wholesale Radio Distributors

711 West Lake Street Dept. A-1 Chicago, Illinois

Where Radio Progress Begins

These views in the laboratory of the Arcturus Radio Company give a graphic picture of the organized experimentation that goes on before a technical advance is announced to the radio public. At the top is the testing room, where every characteristic of a radio receiver or vacuum tube may be accurately measured. Precision condensers, oscillators, resistance and inductance standards, and gain measuring equipment fill this experimenters' paradise. The circle inset shows a corner of the chemical laboratory, where experiments are carried on with the gases and metals that make up a vacuum tube. At the bottom is a complete tube factory in miniature, where the engineers can build any tube they want at a moment's notice. The man at the left is bending over a vacuum tube pump for exhausting experimental tubes. At the extreme left are racks in which tubes are given life tests. Such scenes as this may be duplicated in the laboratory of any wide-awake radio manufacturer.

A RADIO MOVIE DEMONSTRATION

Dr. Frank Conrad, Assistant Chief Engineer of the Westinghouse Electric and Manufacturing Company, with the transmitting apparatus with which he recently demonstrated the radio transmission of moving pictures. At the right is the light source; next to it are the scanning disc and focusing lenses; at the left are the film reels and (in the cylindrical can) the photoelectric cell

Television—Its Progress To-day

By HOWARD E. RHODES

Radio Broadcast Laboratory

LIKE the search of the ancient philosophers for the elixir of life, television has been for years an inspiriting dream of man. Although its first fruits in experimental demonstrations have been shown only in the past few years, the principles on which these demonstrations have been built have been work of several generations of scientific endeavor. The scanning disc, for example, which is an essential part of all the systems being utilized in this country to-day, is the invention of Nipkow, and dates back to 1884. To a considerable extent the problems which it was necessary to solve to make the recent demonstrations possible have been associated with the applications of already known principles, but the future development of the art will be the result of research—the systematic pursuit of knowledge—or the result of some new television tool, and it seems likely, to the writer, that such is necessary to make television really practical.

Enough has already been done in television, however, to excite the interest of everyone. Some stations are now on the air with television, and some are getting ready to go on, so that dyed-in-the-wool experimenters will find it hard to resist the temptation to set up apparatus to receive the broadcasts—even though their quality and program interest is negligible. For the benefit of these experimenters, and also for those interested only in the thrill of "looking in," we here report the progress of television in this country to date. The questions that immediately pop into one's mind—how good are the results, what stations are transmitting, how much does the receiving apparatus cost—are answered as fully as possible. In order that the article might be written with a background of experience, the past few weeks have been spent collecting data and personally seeing several demonstrations.

IN THE July and August issues this magazine published two articles by Mr. R. P. Clarkson which set forth quite clearly the fundamental problems associated with television. By no stretch of the imagination could Mr. Clarkson be considered optimistic in his outlook, and by some he is probably considered decidedly pessimistic in regard to the present methods of approach to the problems of television. It should be realized, however, that Mr. Clarkson was writing from the point of view of one who wished to bring this science from its air-castle fancies back to terra firma. The present article has a different purpose. It is the result of a careful survey—in many cases, by personal visits—of the stations now broadcasting, or about to broadcast television, and its aim is to give the reader information on who is doing the work, how it is being done, and what results have so far been accomplished. —THE EDITOR.

TELEVISION DEMONSTRATIONS

THE first television demonstration seen by the writer which showed promise of being applicable to home use was the demonstration by Dr. E. F. W. Alexanderson at the Schenectady plant of the General Electric Company. This company through three of its stations is now transmitting television signals in accordance with the schedule given in Table 1. The receiver in this demonstration consisted of a scanning disc with a neon tube back of it, the disc being turned by a motor and manually synchronized by varying the resistance of a rheostat.

Essentially similar apparatus was used for part of the American Telephone & Telegraph Company's demonstration, with the difference that synchronization in the latter case was accomplished by means of synchronous motors—a more scientific method of holding the receiver in step with the transmitter, but also much more expensive. To the Telephone Company television constitutes a method of communication complementary to the telephone, and its interest is to develop a system giving quality reproduction. Therefore it cannot consider any system in which synchronization is not positive and automatic. In the same classification fall the more recent tests of this company in which actual outdoor events were televised. The apparatus used was entirely beyond the scope of the experimenter. The experimenter must depend upon other sources for television signals—and who knows hut that some interesting results might come from his work. Even the greatest are sometimes caught napping!

More recently we saw a demonstration at the laboratory of the Daven Company, which has employed Mr. P. H. Koher, a former associate of Doctor Alexanderson, to develop television apparatus for them. In the Daven laboratory, a complete television transmitter and receiver have been constructed, similar in operation and results, so far as the writer can see, to that demonstrated at the General Electric Laboratories. Synchronization of the receiver with the transmitter is accomplished by means of a rheostat in series with the motor, across which a push-button switch is placed. The resistor is adjusted so that the motor tends to turn at slightly below the correct speed; pressing the

TABLE I: WHO IS ON THE AIR WITH TELEVISION SIGNALS

Call Letters	*Location*	*Wave-length Meters*	*No. of Holes in Disc*	*Speed of Disk. (R. P. M.)*	*No. of Pictures Per Second*	*Schedule of Transmissions (E. S. T.)*
WGY	Schenectady, N. Y.	379	24	1260	21	
2XAF	Schenectady, N. Y.	31.4	24	1260	21	Sunday, 10:15-10:30 P. M. Tuesday, Thursday, Friday, 1:30-2:00 P. M.
2XAD	Schenectady, N. Y.	22	24	1260	21	
3XK	Washington, D. C.	46.7	48	900	15	Monday, Wednesday, Friday, 8-9 P. M.
WRNY	New York City	326	48	450	7.5	5-10 minute periods every hour station is on air
2XAL	New York City	32	48	450	7.5	
9XAA (WCFL)	Chicago, Ill.	61	48	900	15	10 to 11 A. M. Daily except Sunday
WMAQ	Chicago, Ill.	447.5	45	900	15	Probably 11:30-12 P. M. Daily
4XA (WREC)	Memphis, Tenn.		24	900	15	Irregular
1XAY (WLEX)	Lexington, Mass.	62	48	900	15	9:30 P. M. Daily
8XAV	Pittsburgh, Pa.	62.5	60	960	16	Irregular

button short-circuits the resistor so that the motor tends to revolve slightly above the correct speed. Successful synchronizing then becomes a matter of getting the knack of pressing and releasing the button at such intervals as to hold the disc at exactly the correct speed. And this is no small job! More anon about synchronizing. As will be pointed out, Jenkins, in our opinion, has a better method.

At the Daven Company's laboratory a pretty young lady was asked to sit in front of the television transmitter located in one corner of the room while the rest of us moved over to the opposite corner where the television receiver was located, the transmitter and receiver being connected electrically by wire. The young lady smiled, winked, smoked a cigarette (these moderns!) and we saw it all in the receiver. The color of the received image is pink—the characteristic glow of a neon lamp. As we recall it, the size of the picture appeared to be about 3″ by 3″.

On August 21, this company held a public demonstration in connection with station WOR. A demonstration for the public, interested in *practical* television, and with little or no interest in *experimental* television, had to be arranged in the form of a show. In this instance puppets were used, as in Punch and Judy, since they are small and their entire movements can readily be reproduced in a small space. The experimenter doesn't care very much about what is sent, being interested in how good the results are, but this demonstration possibly gives us some idea of the technique that will be developed for the first television programs.

A journey to Washington, D. C., to the private laboratory of C. Francis Jenkins, provided one of the most enjoyable days of the investigation. On July 2 Jenkins began the broadcasting of radio movies—i. e., transmitting from a strip of motion picture film—from his experimental short-wave station, 3XK, going on the air every Monday, Wednesday, and Friday night. He has gotten the coöperation of many experimenters, and up to the present his pictures have been received as far west as Chicago and north as far as Boston.

Jenkins demonstrated two different types of television receivers. One of these uses a drum type scanning disc, which has the advantage that it can be made much smaller in size than a flat scanning disc designed to give the same size picture. The drum disc which we saw consisted of a cylinder about 7″ in diameter and about 4″ long, with 48 small scanning holes punched in its peripheral wall and arranged in the form of a four turn helical. A neon light source containing four small plates each about ¼″ square is located in the center, and quartz rods extend from each hole in the wall to the neon tube. This drum with its 48 quartz rods cannot be cheaply made and for the first television experiments a flat scanning disc will prove satisfactory and more economical. We therefore leave a more complete description of it for a later date. Jenkins also had in operation a receiver using an ordinary flat scanning disc from which satisfactory reception could be obtained. This receiver, a picture of which appears in this page, used a small 48-hole scanning disc, the source of light being a small G. E. neon lamp. This lamp gives a picture probably not more than about ¾″ high and about ½″ wide—quite small.

The method of synchronizing is interesting and we found it quite easy to hold the picture stationary. The arrangement used is indicated in Fig. 1. The scanning disc, D, is mounted on a shaft which revolves in the bearing, B. The motor, M, is mounted on a block of wood at a small angle to the disc as indicated, and the mounting block fitted with a slider, fitting into a groove on the baseboard. The screw, S, enables the operator to move the motor to the left or right, parallel to the disc. The end of the motor shaft is fitted with two flanges, F, about 2½″ in diameter with a rubber disc, R, clamped between them. This rubber disc may be made by cutting a 2½″ or 3″ diameter disc from an old automobile inner tube. The motor is so located that the rubber disc bears against the scanning disc at a point about 3″ from the center of the scanning disc. The motor which may be any type, a.c. or d.c., is connected to the line without the use of a resistor and the speed of the disc is adjusted by turning the screw, S, thereby moving the motor assembly further away from or nearer to the center of the scanning disc. With this arrangement the motor runs constantly at normal speed; at least, it runs much more uniformly than when synchronizing by means of a resistor in the motor circuit—the method mentioned previously. We recommend that those who decide to do some television experimenting, start off with this method—although since we are experimenting everyone has a perfect right to try any and every method he can think of to obtain easy synchronizing.

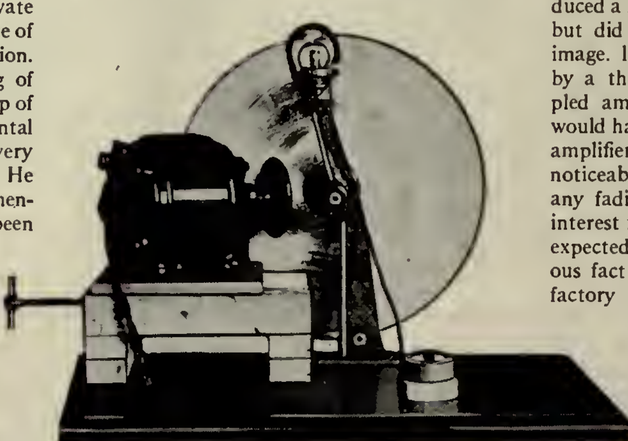
Jenkins at present transmits silhouettes, although he expects soon to transmit ordinary pictures. Silhouettes were used at first so as to keep the side band frequencies within a limit of about plus or minus 5000 cycles. The short-wave channels now being licensed for experimental television are 100 kc. wide, and in a band of this width it is possible to transmit the wide band of frequencies essential for transmitting high quality half-tone pictures. To date, Jenkins has always sent out the same program—a little girl bouncing a ball. In reception the girl and the ball will show up black, silhouetted against the pink background of the neon glow.

A trip was made to Boston a few days later and at this point we succeeded in receiving 3XK, Jenkins' station, and getting recognizable images on a television receiver constructed by James Millen. Static marred reception considerably, but apparently had less effect on television reception than on ordinary broadcast reception which was very poor at the time. At this time we used a large 2′ disc made by the National Company and a Raytheon Kino-Lamp, from which combination can be obtained pictures about 1½″ square.

This test at Mr. Millen's home was made on a Friday between the hours of 8 and 9 P.M. E. S. T. during one of Jenkins' regular transmission periods. Static was very bad, and during the latter half of the demonstration there was thunder and lightning. In spite of this, plus considerable fading, what we considered fairly good results were obtained. The transmission started off with an announcement in both code and phone telling what the program consisted of, after which the actual transmission began. The incoming signals contained components of all the frequencies in the audio band, but the characteristic note in the loud speaker seemed to be about 2000 cycles, probably because the ear is most sensitive to this frequency.

At various times during the hour, especially during those moments when the signal was strong, the silhouettes of our little girl with the bouncing ball could be easily recognized. The static produced a lot of black spots and lines on the picture but did not prevent one from recognizing the image. In this test a short-wave tuner followed by a three-stage high-quality transformer-coupled amplifier was used. Theoretically, results would have been better with a resistance-coupled amplifier but the improvement would not be noticeable unless good strong signals without any fading were being received. This test is of interest for it gives one some idea of what can be expected, and it also indicates the perhaps obvious fact that television reception will be satisfactory at any point at which a good loud-speaker signal can be received.

While at Boston we had hoped to see a demonstration from the local station, WLEX, which has obtained a short-wave television license as indicated in Table 1, but the new 500-watt short-wave transmitter was not yet ready. Before this article is published WLEX will probably be on the air with regular programs.



JENKINS' SCANNING APPARATUS

This rear view of Jenkins' receiving apparatus shows the scanning disc, neon lamp, and driving motor. The screw at the left varies the speed of the disc by moving the friction drive motor along its surface.

Station WRNY of New York has installed a television transmitter and are transmitting programs through their regular broadcasting station and their short-wave station, as indicated in Table 1.

According to a recent release from the Westinghouse Electric and Manufacturing Company, the experimenter will soon be able to look to the station this company operates for programs of radio movies—it will be noted from Table I that this company has obtained an experimental license. A demonstration of radio movies was held in Pittsburgh on August 8th—a demonstration which we, unfortunately, did not see. The system used was in one respect at least, unusual: a mercury arc lamp, magnetically controlled by the incoming signals, we understand, was used in place of the neon tube, the advantage being that much more light can be obtained from the arc than can be obtained from the neon tube so that brighter images are possible. The neon tube doesn't give any too much light. On the other hand, it seems likely that the arc will be more expensive than the neon tube.

Incidentally, the statement in the Westinghouse release to the effect that the demonstration held August 8th, 1928, "was the world's first demonstration of radio movies and possibly the most astounding of the many advances in the science of radio announced in the past year," is rather surprising since, as mentioned previously,

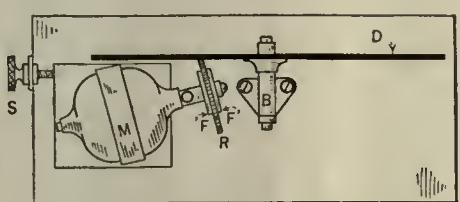


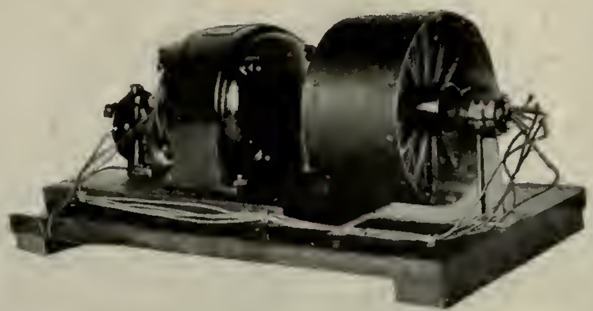
FIG. 1. HOW JENKINS CONTROLS THE DISC SPEED

Jenkins has been transmitting radio movies ever since July 2nd. Furthermore, in the May, 1927, issue of the *Bell Laboratories Record* we read, among other statements, that during research in television, "a strip of motion picture film was projected from a standard machine upon a photoelectric cell. The moving picture of this film was then re-created for an observer by receiving equipment involving a suitable neon tube and a scanning disc." But whether first or last the Westinghouse tests are of interest to experimenters as another possible source of television signals.

APPARATUS FOR RECEPTION

TABLE 1 sums up the situation with as complete a list as could be obtained of those who expect to transmit television signals. The table also gives the data one must have in order to receive the programs. In this connection the important facts are the number of holes required in the scanning disc and the speed of the disc. The column headed number of pictures per second is equal to the speed of the disc in r.p.m. divided by 60. The table shows, among other things, lack of coöperation for as many as five different scanning discs (or one scanning disc with five sets of holes: 24, 36, 45, 48, and 60) would be required to receive all of the stations.

A complete television receiver consists of a tuner, which may be any ordinary broadcast band or short-wave set depending upon whether the signals to be received are being transmitted on the broadcast or short-wave bands. Strong signals are required for the operation of the neon



JENKINS' SCANNING DRUM

This view of the scanning drum shows clearly the quartz rods extending from the holes in the surface of the drum to the neon lamps in the center. The wire connections to the four-element neon lamps are seen at the right

tube. As a basis of comparison we might say that the signals should preferably be strong enough to load up a 171A tube with 180 volts on the plate and a 40-volt C bias. If a transformer-coupled amplifier is used, three stages instead of two may be necessary unless the signals are good and loud. A three-stage resistance-coupled amplifier is preferable, however, especially as quality improves. An amplifier of this type properly constructed will pass the higher frequencies which would be cut off by a transformer-coupled amplifier.

The cost of a television receiver disc neon lamp and motor will vary, depending upon the parts used. Forty or fifty dollars should cover it in all cases. Table 2 shows the companies which are at present manufacturing apparatus for use in television reception.

Complete details for the construction and operation of a television receiver are not given here, but will be the subject of a future article. In these pages we have aimed merely to make clear for the readers of this magazine the present status of experimental television.

CONCLUSIONS

IN RESULTS, none of the demonstrations which we have seen, possibly with the exception of those by the American Telephone and Telegraph Company, first held on April 7, 1927, produces pictures which hold one's interest for any length of time. The present appeal of the art is not one of receiving good pictures, but is to do at home—all by oneself—what is demonstrated in the laboratories of a large corporation with the aid of a thousand engineers, and a million dollars worth of apparatus. When one sees such a demonstration, its greatest appeal—of doing it oneself—is lost, and there remains nothing but comparatively poor reception of the image of a person, made pink-faced because of the characteristic glow of the neon tube in the receiver.

Television, then, is still the province of the experimenter, the man who likes to do h s own pioneering. And to the experimenter it should be among the most fascinating of all the fields of modern scientific advance—because its possibilities are so vast, its perfection so tenuously in the future, and its technique so amenable to new ideas and new ways of doing things. And what does the experimenter, the scientific enthusiast, get out of it? To the world at large, perhaps, pep and a hearty laugh are the attributes of the stock promoter, a fish-tail handshake and absent-mindedness the concomitants of the scientific outlook. Such views, however, must be held by persons who have never been on the inside. The scientist and experimenter get as much fun out of peeping through a spectrobolometer (a device for measuring the energy associated with a spectrum) as does the baseball fan when he catches the ball that Babe Ruth knocks into the stands. They merely get their joy out of life in different ways. C. Francis Jenkins is a shining example in the field of television of the man who is carried on by the sheer joy of being on the inside of a great development. He is sixty years old, and has been working some twenty-five years on photo broadcasting, television and a host of other things, yet he still retains an enthusiasm which seems to charge his whole staff. Jenkins' attitude, that of getting a thrill out of working with something new, and putting together stuff that frequently utilizes some gadgets from the junk box, is that of a born experimenter. Do you want to experiment with television? Then answer this question: Can you get a kick from twisting dials and rheostats for a couple of hours to get finally some fleeting, perhaps hardly recognizable image in the viewing window of a scanning disc? Or do you have to see the previously mentioned Babe Ruth knock a homer to get a thrill?

Although the cases aren't exactly synonymous, think of the thrill Galileo got out of looking through his glass—the first telescope. As a young lad, Galileo used to watch the candelabrum in the cathedral swing slowly to and fro; he timed its motion by the pulse beat in his wrist, and thought of using such a device for the measurement of time. In later life he invented the telescope, and with it saw thousands of stars never before seen by man. In 1610 he wrote to Kepler:

"Oh, my dear Kepler, how I wish that we could have one hearty laugh together! Here, at Padua, is the principal professor of philosophy, whom I have repeatedly and urgently requested to look at the moon and planets through my glass, which he pertinaciously refuses to do. Why are you not here? What shouts of laughter we should have at this glorious folly! And to hear the professor of philosophy at Pisa laboring before the Grand Duke with logical arguments, as if with magical incantations to charm the new planets of the sky." Some joy is surely to be derived from doing what hasn't been done a thousand times before.

TABLE II: WHO IS MAKING TELEVISION APPARATUS

Name of Manufacturer	*Apparatus*
Daven Corp.	Motors, scanning discs (either 24, 36, or 48 holes), neon tubes, rheostats for controlling motor speed, completely assembled resistance-coupled amplifiers. Complete kit for about $45.00
Insuline Corp. of America	Complete kit listing for $52.50, containing scanning disc with either 24, 36 or 48 holes, motor and control apparatus, magnifying lenses (to make the picture appear larger), hardware
National Co.	48-hole scanning disc. Price: $15.00
Raytheon Mfg. Co.	Kino Lamp. A neon lamp with 1½" plates for use in television receivers. Price: $12.50
Interstate Electric Co.	Type M2V Baldor television motor. Price: $23.00

A Nine-Tube Screen-Grid Super

By ROBERT BURNHAM

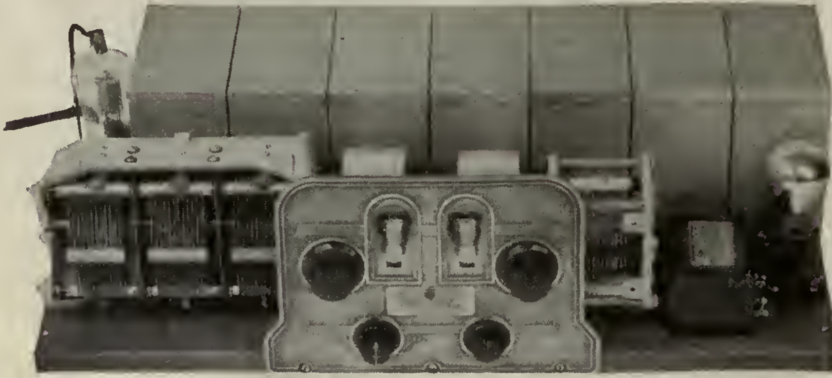


FIG. 1. THE RECEIVER WITHOUT THE CABINET

Compact construction makes this nine-tube super-heterodyue occupy a smaller space than most receivers of the same number of tubes. All the tubes except the antenna input and audio tubes are housed in the shield cans in the rear.

WITH the steady increase in the number of broadcasting stations operating in the frequency band of 550 to 1500 kc. that has taken place in the last several years, the efficacy of the super-heterodyne system of reception has gradually dwindled, for the characteristics of the typical super are such that the effective selectivity of the oscillator dial is practically halved due to the basic principle of the system. This and the accompanying fact that the average super-heterodyne, besides repeating stations at two or more points on one of the two tuning dials, will bring in a multiplicity of heterodyne squeals, has militated against the advantages of this system, such as the high amplification possible, until to-day it is quite safe to say that a good 6-tube screen-grid t.r.f. receiver will outdistance an ordinary 7 or 8-tube super-heterodyne in the matter of actual distance reception, primarily due to the greater effective selectivity rather than to the greater sensitivity of a t.r.f. set. The usual method of obviating repeat points upon a super-heterodyne is to use an intermediate frequency so high that the separation upon the antenna tuning dial of two stations which may be heterodyned by a single given oscillator adjustment is so great that the repeat point is either beyond the required oscillator range (for the majority of signals) or so far separated as to impose no undue selectivity requirement upon the antenna circuit. This system in a measure vitiates the principal advantage of the super-heterodyne which is the higher amplification, obtainable at low radio frequencies, than may be had at such high intermediate frequencies as are encountered in the r.f. amplifier of a t.r.f. set or as are necessary in the i.f. amplifier of a successful one-spot super. This factor makes some one-spot super-heterodynes actually inferior to a good t.r.f. set of two less tubes!

Bearing in mind that a low intermediate frequency is necessary to realize the full amplification possibilities of the super-heterodyne system and that the frequency changing feature of the super-heterodyne must in no way be relied upon to provide adequate selectivity under present broadcast conditions, the receiver pictured and described herewith was developed. As it has been developed, this receiver does not depend upon the selectivity usually obtained in the intermediate-frequency amplifier at the expense of tone quality, or upon the apparent selectivity resulting from the frequency changing action. To provide a high degree of selectivity, the input to the first detector has instead been designed to provide in itself practically all of the selectivity required for this rather unusually sensitive set. This end is attained through the use of a 3-stage radio-frequency amplifier, tuned by a 3-gang condenser to any desired wavelength. This amplifier is sufficiently selective in itself to provide effective selectivity and at the same time a high degree of r.f. amplification. By this means the super-heterodyne system has been freed of any drawback resulting from oscillator dial repeat points attendant upon the use of the low intermediate frequency necessary to provide really high amplification; and at the same time the disturbing effect of heterodyne squeals has been practically done away with, even when the receiver is operated in such congested centers as New York and Chicago.

MANY of us have probably operated a super-heterodyne which would tune-in a single powerful local station at four and sometimes six or more points on the dial. This condition is due to two factors: (a) insufficient selectivity in the tuned circuits preceding the first detector, and (b) the generation of harmonics by the oscillator. There are two methods of overcoming these difficulties. One of these methods is to raise the frequency at which the intermediate amplifier is designed to operate to a value such that the second point (and the harmonics) of the oscillator cannot, for practically all dial settings, beat with any station except the one desired to produce the proper frequency to be amplified by the intermediate amplifier. This method was used in the receiver described by Mr. W. H. Hollister in the September issue.

The second method of making fool-proof the operation of a super, uses one or more stages of ordinary r.f. amplification ahead of the first detector, so that practically all the required selectivity (as well as some gain) is obtained in this amplifier; the intermediate amplifier then functions to amplify greatly the signal without being also called upon to supply all of the necessary selectivity. The receiver described in this article employs this second method.

—THE EDITOR.

THE DESIGN OF THE RECEIVER

IN FIGURE 1, the receiver is seen with the cabinet removed. The set has been designed to be enclosed in a console or table cabinet to suit the builder's fancy, though it is particularly adapted to the new S-M metal cabinet which adds to the effectiveness of the shielding in the set. Figure 4 shows the details of the receiver assembly with the copper stage shields which enclose all r.f. circuits removed, and with all parts labeled as in the parts list. In Figure 2 is the schematic circuit diagram of the receiver, while Figure 3 shows the set with tubes in place but shields removed.

The receiver consists essentially of a three-stage broadcast band t.r.f. amplifier employing three screen-grid tubes and a screen-grid first detector. Coupled into the screen lead of the first detector is the oscillator, which is of conventional type. Following the first detector is the two-stage 65-kc. intermediate amplifier and the second detector. All of these circuits are individually shielded in small copper cans with removable sides and tops for easy access. Following the second detector is a single stage of audio amplification utilizing the new Clough system. The receiver is intended to operate with an external power amplifier in order to provide a high degree of tone quality. Because of the desirability of a 210 or 250 type output tube to prevent overloading it has been thought best to omit this last stage tube from the receiver assembly. Despite the apparent complication of the r.f. amplifiers involved, the control of the receiver is simplicity itself, for the 3-gang t.r.f. amplifier condenser is controlled by the left-hand drum dial of Figure 1, while the oscillator condenser is controlled by the right-hand dial. Sensitivity of the t.r.f. amplifier is controlled by the small knob at the lower left of the control panel escutcheon, R_1. This adjustment takes the form of a potentiometer which varies the screen-grid potential of the

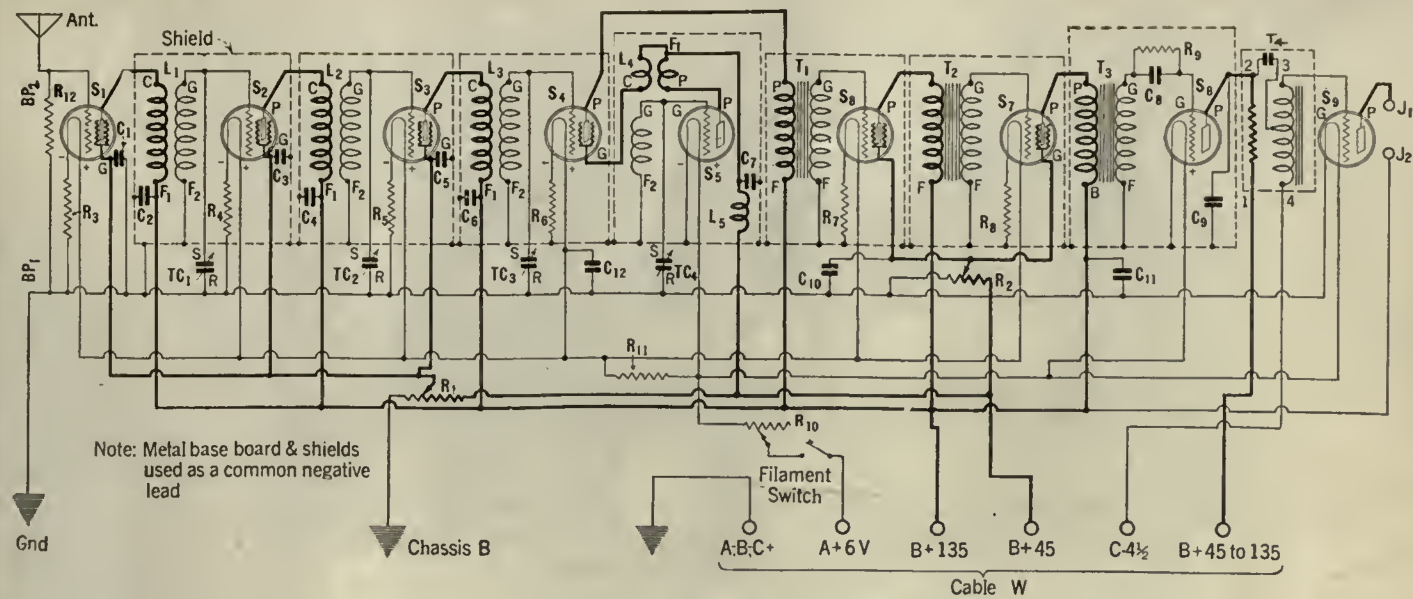


FIG. 2. THE SCHEMATIC DIAGRAM

tubes. A similar potentiometer, R_2, at the lower right of the control panel escutcheon carries an on-off switch attachment and serves to vary the screen potential of the two intermediate amplifiers. The r.f. amplifier employed is very similar to that found in the 6-tube receiver described upon pages 281–283 of the September issue of RADIO BROADCAST, except that in this super-heterodyne a dummy input tube is utilized to simplify tuning (since there is amplification and sensitivity to spare) and a screen-grid first detector is employed. The 222 tube is used here for a number of reasons, among them the fact that the effective selectivity of the first detector circuit is somewhat greater than would be the case were a 201A to be used with the same circuit arrangement.

The receiver is mounted upon a steel chassis $21\frac{7}{8}$″ long, $9\frac{15}{16}$″ wide, and $\frac{5}{8}$″ deep. At the left end (as in Fig. 4) is the first r.f. tube. Its grid circuit is connected across an antenna resistance, R_{12}, attached beneath the chassis to ground and antenna binding posts BP_1 and BP_2. This tube feeds the two tuned r.f. amplifier stages utilizing tubes S_2 and S_3, while S_3 feeds the detector stage including tube S_4. The three tuned circuits are identical and employ r.f. transformers having secondaries consisting of $98\frac{1}{2}$ turns of No. 29 enameled wire wound upon a threaded bakelite tube in a space $1\frac{1}{2}$″ in diameter and $1\frac{1}{2}$″ long. These secondaries are tuned by sections TC_1, TC_2, TC_3 of the 0.00035-mfd. die-cast gang condenser (each section is equipped with an individual trimmer). The r.f. transformer primaries are wound with 35 turns No. 38 wire upon a $1\frac{1}{4}$″ tube placed at the filament end of the secondary. Individual 10-ohm filament resistors are used for each of the first four screen-grid tubes and the screen-grid and plate circuits are bypassed by $\frac{1}{4}$-mfd. condensers to provide very short r.f. paths and thus prevent disturbing interstage coupling. In preliminary tests it has been found that if the plate lead of the detector tube, S_4, is removed from the P post of the first intermediate-frequency transformer and instead is connected to post No. 2 of the first-stage audio transformer, that the t.r.f .receiver resulting will provide very satisfactory distance reception over a range of several hundred to one thousand miles or more, and selectivity which in itself is considerably greater than that obtained from many ready-made receivers. This arrangement may be resorted to for preliminary testing of the receiver. (While a screen-grid detector tube would not work into an ordinary audio transformer at all satisfactorily, the characteristics of the Clough audio system are such that a screen-grid detector may feed directly into a transformer of this type with a quite satisfactory resultant frequency characteristic.)

The oscillator coil, L_4, has a grid winding equivalent to the r.f. transformer secondaries and in addition a coupling coil consisting of 35 turns of No. 34 d.c.c. wire on a $1\frac{1}{4}$″ tube and a tickler coil wound in a slot at the bottom of the form consisting of 35 turns of No. 34 d.s.c. wire. The grid winding of the oscillator is shunted by the 0.00035-mfd. condenser, TC_4, controlled by drum dial D_2. A small r.f. choke coil, L_5, is placed directly under the oscillator coil base with its axis at a right angle to the axis of the oscillator coil. (The oscillator and t.r.f. coils are wound upon moulded S-M plug-in forms which fit any standard 5-prong tube socket.)

In working upon the intermediate amplifier, a number of different transformer designs were evolved and tested, and in the course of this work the possibilities of standard i.f. transformers now on the market were investigated. The S-M 210 transformers which are normally broad-band iron core types were found to give excellent results with screen-grid tubes and due to their comparatively small primaries, functioned as rather sharply tuned transformers, giving an amplification of 65 per stage at 65 kc. and a band width of about 10 kc. at forty per cent. of maximum amplification—a quite satisfactory characteristic for an intermediate amplifier.

The intermediate amplifier tubes are S_6 and S_7, the second detector S_8, and the three i.f. transformers are T_1, T_2, T_3. The second detector employs a grid condenser and leak for rectification, while the first detector has really no means provided to effect rectification. While this may seem peculiar, it was observed in operating tests that due to the effect of the impressed oscillator voltage, very satisfactory detection was obtained even though none of the usual precautions were employed in the circuit to insure it. This being the case, it was thought best to take advantage of this propitious condition and discard the usual adjuncts to rectification, such as grid condenser and leak or C battery, which seemed only likely to add complications without any resulting gain to the receiver.

In actual operation this 9-tube super-heterodyne operating into a power amplifier stage has allowed reception of weak out-of-town stations within 10 kc. of any Chicago local station when the receiver was operated in residential districts. In comparative tests against other receivers, it was found that this super-heterodyne would in every case show a considerably higher noise level

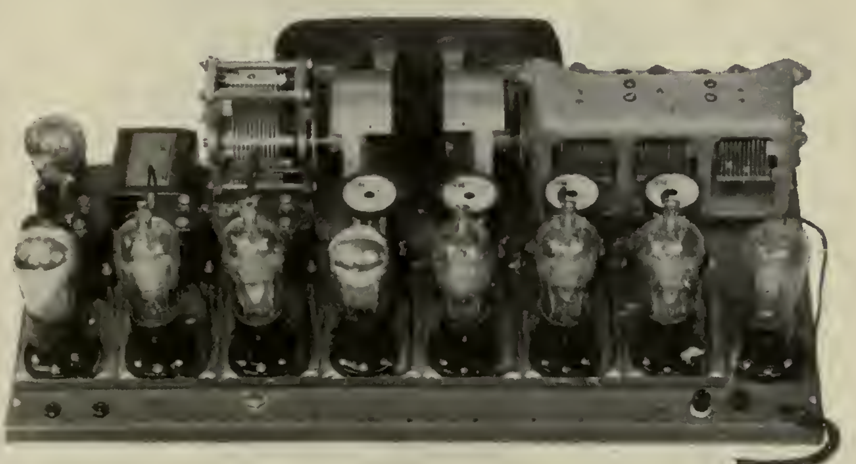


FIG. 3. WITH THE SHIELDS REMOVED

Screen-grid tubes are used in the three r.f. stages, the first detector stage, and the two i.f. stages. A CX-301A tube is used for an oscillator, and 112A tubes in the second detector and first audio sockets.

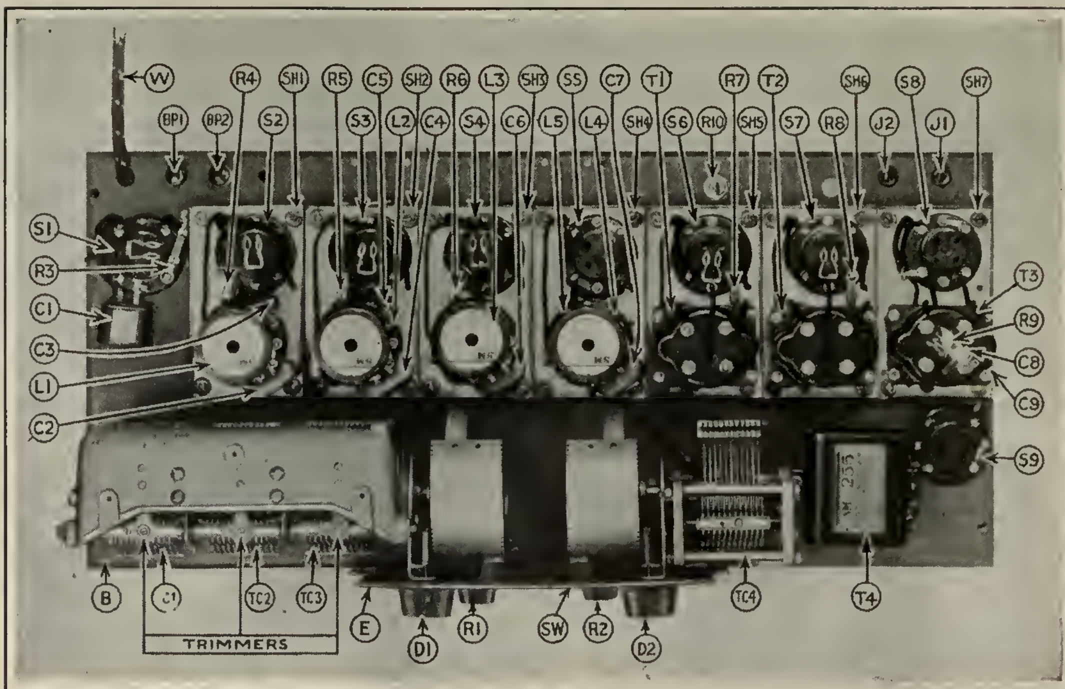


FIG. 4. THE RECEIVER SEEN FROM ABOVE

when adjusted to maximum sensitivity. This condition was thought to indicate a very satisfactory degree of sensitivity indeed—a value so high that it could not be utilized in the warm, summer weather due to the high noise level. During preliminary tests small 50 and 100-watt stations 1000 or more miles away were received with loud speaker volume, and the more powerful stations on the Atlantic and Pacific coasts, and in fact in all parts of the country, were received with excellent volume whenever the noise level was low enough to let these stations be separated from the noise.

CONSTRUCTION AND OPERATION

THE construction of the receiver itself is quite simple. The parts employed in the model described herewith are listed at the end of this article, the listings being accompanied by the designating letters seen in the various illustrations and in the circuit diagram. Despite the apparent complexity of the circuit, the receiver is very simple to put together for it is built up upon a very ingenious pierced steel chassis which is available in the open market. On this chassis, which incidentally is suited to the mounting of a number of different types of receivers, all necessary wiring and mounting holes are pierced so that to assemble the set it becomes necessary merely to put the various parts in the different stage shields as seen in the photographs and then to bolt these stage pans to the chassis itself, along with a few other parts. The wiring is quite easily handled, as all leads are short and direct and the use of the metal chassis as the A minus, B minus and C plus common circuit return eliminates a large number of connecting wires. The only parts mounted beneath the chassis are the three 1-mfd. bypass condensers, C_{10}, C_{11}, C_{12}, the antenna resistance, R_{12}, and the rheostat, R_{10}, (the adjusting screw of which is visible in Figure 4). The connecting cable used simplifies the battery connection to the receiver and eliminates the multiplicity of binding posts ordinarily used for this purpose.

The testing and operation of the receiver is most simple, it being necessary after it has been assembled, wired, and checked, merely to connect the necessary A and C batteries (or light-socket power units) to the battery cable and then to connect the proper leads of the cable to the B-voltage binding posts of a single-stage power amplifier and B supply. (The receiver may not be operated satisfactorily from dry B batteries, since the current drain on the 45-volt circuit is approximately 30 milliamperes—though the total current drain of the whole receiver is only 40 mA). A good standard B-power supply should be used for the set if a power amplifier is not employed, though the latter is distinctly desirable since it is never wise in the interests of good tone quality to operate a loud speaker directly out of a single audio stage following a detector tube. Nevertheless, this may be done for test purposes and until the builder can afford an amplifier, for the receiver will give very good loud speaker volume without the use of a power output stage (which should preferably be a 210 or 250 push-pull stage).

In operation, stations are tuned in upon the Selector I and Selector II dials, and volume and stability is adjusted by means of the two small knobs on potentiometers R_1 and R_2, the set is turned off by turning R_2 to the *off* position. The stations will be received at only one point upon the left-hand dial and at two points upon the right-hand dial. This condition, however, is no disadvantage, for the selectivity of the r.f. amplifier is so great that there is never any possibility of two stations, for which a single oscillator setting will serve, coming through the receiver at one time—the short-wave t.r.f. amplifier absolutely prevents this usual source of super difficulty. This receiver cannot be operated at maximum amplification adjustments except in locations having a most unusually low noise level and under the best of weather conditions, for the sensitivity of the receiver is such that in ordinary residential districts noises not heard on most receivers can be brought in with ear-splitting volume; and of course many weak stations ordinarily not heard come in with them. This, however, is no disadvantage, for by turning down the gain controls of the receiver local programs can be received with quietness, freedom from interference, and satisfying tone quality obtainable from few other radio sets.

LIST OF PARTS

THE substitution of electrically and mechanically equivalent parts may be made in the list below, at the builder's choice. The apparatus in kit form, with all the necessary hardware, is obtainable from several mail order houses, at about $96.00 list price.

B—1 S-M 701 universal pierced chassis
BP_1, BP_2—2 moulded binding posts, consisting of $\frac{8}{32}$ screw, nut, and moulded top
C_1 to C_7—7 $\frac{1}{4}$-mfd. midget bypass condensers
C_8—1 0.00015-mfd. grid condenser with clips
C_9—1 0.002-mfd. bypass condenser
C_{10}, C_{11}, C_{12}—3 1-mfd. bypass condensers
D_1—1 S-M 806L (left) vernier drum dial
D_2—1 S-M 806R (right) vernier drum dial
E—1 S-M 809 dual control escutcheon
J_1, J_2—2 Yaxley 420 insulated tip jacks
L_1, L_2, L_3—3 S.M 132B plug-in r.f. transformers
L_4—1 S.M 132C plug-in oscillator
L_5—1 S-M 275 choke
R_1, R_2—2 Yaxley 3000-ohm midget potentiometers, type 53000
R_3 to R_8—6 Carter RU10 10-ohm resistors
R_9—1 2-megohm grid leak
R_{10}—1 Carter A3 3-ohm sub-base rheostat
R_{11}—1 Carter H$\frac{1}{2}$ $\frac{1}{2}$-ohm resistor
R_{12}—1 Durham 150,000-ohm resistor
S_1 to S_8—8 S-M 511 tube sockets
S_9—1 Naald 481XS cushioned tube socket
SH_1 to SH_7—7 S-M 638 copper stage shields
SW—1 Yaxley 500 switch attachment
T_1, T_2, T_3—3 S-M 210 long-wave transformers
T_4—1 S-M 255 first-stage a.f. transformer
TC_1, TC_2, TC_3—1 S-M 323 3-gang condenser, 0.00035-mfd. in each section
TC_4—1 S-M 320R 0.00035-mfd. Universal condenser
4 S-M 512 5-prong tube sockets
1 S-M 708 10-lead, 5-foot connection cable
2 S-M 818 hook-up wire (25 ft. to carton)
1 Set Hardware (furnished by Set Builders Supply Co.)

To make the set operative, the following accessories are necessary:

6 CX-322 tubes
2 CX-112A tubes
1 CX-301A tube
Power amplifier (210 or 250 push-pull preferable)
B-power unit (135 volts maximum)
Source of A and C voltage

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

The Low-Power Stations Plead Their Case

AT THE recent series of hearings before the Federal Radio Commission, a hundred stations attempted to show cause why they should be allowed to continue in operation. The evidence proved to be a most comprehensive presentation of the case of the smaller broadcasting station. So eloquently did some of the owners of the condemned stations present their story that many a hard hearted enemy of broadcasting congestion felt that means must be devised to take care of as many worthy local stations as possible. Not only must the rights of listeners to good reception be considered but also that of communities to broadcast.

The whole question is: To what degree shall good reception for the greatest number and the widest areas be sacrificed to the self-imposed wish of a minority of communities to broadcast? No one would oppose extension of broadcasting facilities to any community, however small, did not such a policy inevitably restrict enjoyable listening to that limited number within the high grade service area of a local station. But even disregarding the listener's rights entirely, how many of the insatiable host of radio advertising stations, most of them parading before the commission as altruistic local service stations, could be accommodated were the entire broadcasting band devoted to their exclusive use?

In spite of the obvious local sentiment for the continuance of some of these community stations, the statement remains unrefuted that no great number of them can be taken care of without making high-power broadcasting impossible. From the engineering standpoint, the capacity of the ether is strictly limited to a definite number of stations of a given power per channel, separated by a definite minimum distance. As early as March 24, 1927, a member of the staff of RADIO BROADCAST presented to the Federal Radio Commission a comprehensive plan for broadcast station allocation which definitely appraised the station capacity of the broadcast band and provided for equitable distribution of channels by areas. The plan proposed that the United States be divided into areas 500 miles square, and laid out a definite quota of high-power, regional and local stations of various powers which could be accommodated for simultaneous operation in each area. It pointed out that the Commission's first task was to appraise the capacity of our 89 broadcast channels and then allot their facilities equally to specific areas. Only now is the Commission beginning to do all of these things.

With respect to local service stations, the plan pointed out that 50-watt stations, providing "high grade" service for three miles and "satisfactory" rural service for 22.5 miles, were adequate to meet the requirements of local communities broadcasting for the benefit of a particular city and its environs and would make it possible to provide such facilities for the greatest possible number of cities. Several stations of that power can be assigned to the same channel, if separated by a minimum of 500 miles. Were all of our 89 channels assigned to this service exclusively, there would be a maximum of 1157 local service stations. The maximum area receiving satisfactory service would be 1,839,630 square miles, or approximately half the area of the United States. Assuming equal geographic spacing, there would be a carrier on every dial setting of the receiver, but a program of satisfactory strength could be received in half the area of the country on but one dial setting. *The other half of the country would have no "satisfactory" service whatever.* No allotment would be made to higher powers on this basis, so that the listener, tiring of his one local station, could not take advantage of high grade regional stations.

STATION POWER AND SERVICE RANGE

Station Power in Watts	No. in U. S. per Channel	Separation in Miles (min.)	Range Miles: High Grade	Range Miles: Satisfactory	Area Served Sq. Miles: High Grade	Area Served Sq. Miles: Satisfactory
50	13	500	3	22.5	7	1590
500	3	1250	10	65	314	13,273
5000	1.5	3000	30	160	2827	80,427
50,000 or over	1	6000	90	360	154,470	407,150

The other extreme which could be adopted would be to give virtually no consideration to the rights of communities by assigning all channels to super-power stations endowed with exclusive channels. This would provide a maximum of 89 stations of 50,000 or 100,000 watts. A station of 50,000-watt power has a "high grade" service range of 90 miles and a "satisfactory" service range of 360 miles. The total area receiving "satisfactory" service coverage from 89 such stations would be 36,236,350 square miles. Therefore, were these stations spaced equidistantly, there would be twelve 50,000-watt stations within 360 miles of every point in the United States. The high-grade service coverage would be 13,747,830 square miles. In other words, the listener would have a choice of four stations within high grade service range and twelve within satisfactory service range, no matter where he was located. With 1157 50-watt stations, only 8099 square miles of the United States would have high grade service.

Any plan of allocation is a compromise between these extremes. Either few communities will have radio as a medium of expression, while the listener, no matter where he is located, will have a considerable choice of powerful stations, or else many communities will have opportunity to place themselves on the air for local service while the actual area getting high grade service would be significantly reduced.

The table on this page, taken from *Using Radio in Sales Promotion*, gives the average number of stations per channel, their minimum separation and their service ranges and areas. The average of one and a half stations per channel of 5000 watts is based on the fact that two stations of such power may be placed at diagonal extremes of the United States, while in any other location the 5000-watt station must have an exclusive channel. The table also shows that there is no gain in frequency space by reducing the maximum power from 100,000 to 10,000 watts, or any other such figure, as is often suggested, because a 10,000-watt station takes as much ether space as a 100,000-watt station.

The most important argument against the high-power station is that the total *number* of radio broadcasting stations in the United States is reduced in proportion to the number of high-power stations permitted. A few large stations naturally tend toward the centralization of broadcasting in a few organizations, because high-power stations are unprofitable unless they draw upon the finest possible program sources and the most fruitful revenue producing programs. The other extreme is in the establishment of many community stations of low power and necessarily of low program merit.

It is our opinion that the low-power station should be encouraged in sparsely populated sections where there is no reasonably good service from high grade stations, but that in populous areas, with many independent broadcasting sta-

JUST BEFORE MAKING RADIO HISTORY

At Signal Hill, Newfoundland, Senatore Marconi, in the center, Mr. G. S. Kemp (left) and Mr. P. Paget (right) are pictured with a basket containing a balloon that they hope will carry an antenna on which to receive radio signals from Poldhu, England, Time: December, 1901. The balloon was carried away in a gale, but a kite was used, and the historic letter "S" came through from England—the first transatlantic radio signal ever received.

tions, the standard should be reasonably high. Radio, after all, is not for the benefit of the broadcasting station management or owner, but for the listener. To the average listener it represents a greater sacrifice to restrict the range of regional and national stations, a real program loss to immense areas, than to lose the chamber of commerce and the local glee club program, indifferently released by an inadequately financed and low-power local broadcasting station.

The evidence brought before the Commission in behalf of the local stations was almost entirely drummed up by the station managements themselves and tended to produce an exaggerated conception of their local service, not always shared by the listeners. The large, loyal followings and the program merit of the high grade, high-power stations is axiomatic and has never required substantiation in the form of affidavits by politicians. Let us place the right of the listener to hear above that of the politician to shout.

SPECIFIC EVIDENCE FOR THE SMALL STATION

MOST of the evidence brought before the Commission was in the form of impassioned speeches by station owners, supported by local politicians. Senator Curtis of Kansas, for instance, swore out an affidavit in behalf of WGL of New York City, a station notorious for consistently wretched quality of transmission and mediocrity of programs. The one occasion on which it really attracted attention to itself was when it proposed to broadcast the mutterings and shriekings of the inmates of an insane asylum. With such examples as these, the Commission undoubtedly discounted greatly any evidence put into the record by politicians whose objective was obviously to win local sentiment rather than to help broadcasting.

Some stations were able to show specialized local service of considerable merit. It is for just such stations that we urge a limited number of local service channels. The fact that good local stations are supported by local advertising accounts is to their credit, in that it assures their economic independence and the fact that, in the opinion of advertisers at least, they have substantial audiences.

In the most unfortunate plight were those stations charged with excessive frequency deviation. Some of these were able to show that they employed the utmost diligence in checking their frequencies against crystal oscillators purchased from companies of the highest repute. Because the crystals were inaccurately calibrated or because months were mysteriously required for their delivery to the station, these stations had no means whatever of maintaining themselves upon their assigned frequencies. Their difficulties were further complicated by the fact that, at the higher frequencies, stations are assigned with closer geographic spacing and the effects of deviation are more disastrous as the frequency increases. In so many instances were the station's troubles laid at the doors of incompetent crystal grinding that alarmists were ready to charge that a conspiracy was on foot to destroy smaller stations by supplying them with inaccurately calibrated crystals.

Without an accurately calibrated crystal, it is impossible to maintain a station on its frequency. Only by diligent observation and constant checking against an accurate crystal can a station maintain its correct position in the broadcasting spectrum at all. Occasional deviation is unavoidable; consistent deviation inexcusable. The present standard of 500 cycle maximum deviation is reasonable, but license revocation for a few violations is entirely too drastic a measure in the present state of the art. Suppliers of crystals, in a position to grind them to the accurate requirements of broadcasting, are few in number. Instead of accepting the responsibility attendant upon that position and giving the substantial aid they might to the conscientious broadcasters, these few suppliers allow months to pass between the acceptance and filling of an order and are not above blaming the Government's measures, rather than the defects of the crystal, when a crystal is found to be off frequency.

Regulations for Television and Picture Transmission

CONSIDERING the rapid spread of picture broadcasting from coast to coast and the known intention of a great many additional broadcasting stations to undertake television and the broadcasting of radio pictures this fall, the Commission's announced intention to apply regulation to this new form of program is a matter of general interest to the broadcast listener and the management of broadcasting stations.

There are two classes of image transmission to consider: (1) those systems involving the use of the conventional radio telephone broadcasting equipment, capable of radiation upon the standard broadcast channel without infringing upon neighboring channels; and (2) those using new methods of transmission and attempting the radiation of an excessive number of image impressions so that they radiate signals audible on neighboring channels.

Before regular audiences are established for the latter type, which appears to include every attempt at television transmission so far made, regulatory orders should be issued which definitely limit all transmission in the broadcast band to a maximum channel width allowable without interference with neighboring channels. The Commission would be placed in a most embarrassing position if it found broadcasting disrupted by television signals, after thousands of listeners had equipped themselves with scanning discs and neon tubes in the attempt to receive these signals as television images. There should be no attempt to throttle the development of television, but traffic evils in the ether cannot be safely disregarded. The Commission is fully empowered by the Radio Act to "regulate the kind of apparatus used with respect to its external effects and the purity and sharpness of the emissions from each station and from the apparatus therein." It may therefore require that transmissions in the broadcast band be kept within definite 10-kilocycle limitations. Certain television transmissions in the broadcast band can now be heard twenty, thirty and even fifty kilocycles above and below the channel assigned to the station radiating them.

As for picture transmissions, however, which do not involve any new character of signal with respect to "external effects and purity and sharpness of emissions," the Commission's jurisdiction is limited to their bearing upon public convenience and necessity. Picture transmissions made with the conventional radio telephone broadcasting stations are purely matters of program. They are for a special class of broadcast listener whose radio receiver has a picture-making attachment, but these listeners are no more a special class than are owners of farms for whom special farm programs are radiated, or foreign language groups which are often favored by special programs of no interest to any other listeners.

The Commission is distinctly barred from regulating radio programs. It is doubtful whether the Commission may prescribe that a station shall not serve those of the radio audience desiring to receive pictures except within certain limited hours, any more than it may restrict the time devoted to philosophical lectures, jazz music

THE MOST SOUTHERLY STATION

Until Commander Byrd gets to work in the far south, this station at Prince Olaf Harbor, South Georgia, will have the honor of being the most southerly of radio-telegraph stations. It employs a 500-watt Marconi telephone-telegraph transmitter, and it is used to control the movements of whalers in antarctic waters. This photograph was taken in the summer, when for a short time the snow partially disappears and a few plants may be seen.

or direct advertising. Picture broadcasting is a general service of pictures into the home. For the present, this is a service principally to experimenters and pioneers—the same class which initiated the broadcast boom in 1920—and it is unfair to pass special regulations restricting the service to that growing group.

However, in one sense, the desired objective of the Commission to restrict picture signals to hours such that the public, seeking musical entertainment, shall not be too frequently disturbed by picture signals, has already been attained. Ninety per cent. of all picture transmissions take place during daylight hours when the stations involved have heretofore been customarily silent. No program director is prepared to force picture signals upon an audience predominately interested in tone reception, especially between the hours of eight and eleven in the evening, and the maximum weekly schedule of the stations now broadcasting pictures through out the United States involves less than twenty minutes of actual picture signal per week. This is certainly not too great a concession to the experimenter who looks forward to the day that illustrated radio programs will be received in every broadcast listener's home. In spite of the doubtful validity of a regulation applying program restrictions, there is really no opposition to the Commission's proposed course in limiting the number of picture transmissions permissible.

HOW IT'S DONE IN JAPAN

Nipponese broadcasters use Western apparatus (in this case a Marconi 10-kilowatt transmitter), but they manage to create the atmosphere of a Japanese print even in so mechanistic a background as this. The photograph shows the modulator and amplifier panels of Station JOBK at Osaka, one of Japan's leading broadcasting stations.

Here and There

THE Army Air Corps, according to F. Trubee Davison, Assistant Secretary of War for Air, will install radio beacons at Mitchel Field, N. Y., San Francisco, Cal., San Antonio, Texas, Uniontown, Pa., Dayton, Ohio, and Washington, D. C. Experiments prove that the range of these beacons may be extended up to 2000 miles, if required.

CHIEF Radio Supervisor W. D. Terrell has issued an order to amateur and experimental stations, effective October 1, that they use the intermediate "w," if located in continental United States, and "k," if in our territories or insular possessions, in accordance with the plan adopted by the International Radio Telegraph Convention.

A STUDIO is being installed in the new administration building of the Board of Education of Pittsburgh, Pa., in order that educational programs may originate there for radiation by KDKA. Practically every school in Pittsburgh has been equipped with a receiving set and, at specified times, lessons on a particular subject will be broadcast to all pupils of all schools of a certain grade. Educational work of this nature has been carried on in England for several years. More than 4000 schools in London and Daventry are equipped to receive programs radiated through the British Broadcasting network.

Another experiment along educational lines was conducted for a period of six weeks last season by WEEI of Boston, and will soon be resumed on a more elaborate scale. From one to one-thirty o'clock on Tuesday and Thursday afternoons, the students of the S. A. Day Junior High School of Newtonville held classes in the assembly hall before the loud speaker. The success of the project was so marked that many schools were equipped with radio receivers during the summer. The subjects taught last season were French, poetry, music, science, history, and geology.

CONTRIBUTIONS ranging from fifty cents to two dollars were received by Tex Rickard as expressions of thanks from members of the radio audience for making possible the broadcasting of the Tunney-Heeney fight. Rickard, upon receipt of these donations, expressed the opinion that they were evidence that the broadcasting companies have been receiving something good for practically nothing for a long time. His contract with the N. B. C. soon expires and the probabilities are that Rickard's peace conferences will not be broadcast for some time to come. Eventually, however, a commercial sponsor will probably be found for them.

THE Columbia Broadcasting System has concluded arrangements with Station WABC, operated for some years by A. H. Grebe & Company, to become its alternate New York key station on the evenings that WOR is not available. Columbia chain programs have thereby become nightly affairs. WOR has also relinquished Sunday afternoons and evenings in favor of WABC.

ADVERTISERS are spending from ten to twelve million dollars yearly in presenting good will programs through radio, according to Frank A. Arnold of the National Broadcasting Company. This, it seems to us, is greatly underestimated, since it does not take into account the money spent on local stations for advertising announcements.

THE number of stations deleted from the list of broadcasters as a direct result of the notification to show cause, served on 164 stations, amounted to but 36. All but 57 of the cited stations appeared at the hearings with witnesses and affidavits, and 21 stations filed affidavits by mail.

CAPTAIN S. C. HOOPER has been made Director of Naval Communications to succeed Rear Admiral Craven, who has been made commandant of the naval training station at Great Lakes, Ill. Captain Hooper has been temporarily assigned to the Federal Radio Commission as short-wave expert.

A LIST of frequency assignments for special services on short waves was announced by Captain Hooper, just prior to his appointment as Director of Naval Communications. Six channels were reserved for communication between airplane and ground stations; five channels for communication between ships, ship-to-ship and coastal stations by radio telephony; one channel for police departments; three marine calling frequencies; two groups of frequencies comprising eleven channels for experimental purposes; five for geo-physical purposes; six for railway communication between engine and caboose; four for scientific expeditions and yachts, in addition to their usual calling frequencies; three for portable stations and twenty for power line control. This latter generous allocation should certainly satisfy the power companies.

APPEARING before the Federal Radio Commission on May 14, 1928, to request a great number of 100-kilocycle width channels for television purposes, Dr. Alfred N. Goldsmith of the Radio Corporation of America stated: "Radio television is at a stage where it is prepared to leave the seclusion of the research laboratory and to enter into the daily affairs and uses of men. Intensive development work of an experimental nature has already been carried on and transmission of television material is at hand through confidential experiments and transmissions carried on at Schenectady, Pittsburgh, and New York. In other words, television is not a vague and remote project, but, while still experimental, is an imminent and plausible possibility."

After pointing out that uninformed television broadcasters would transmit an endless series of unsatisfactory pictures which would benefit only oculists in the proportion that they would ruin the eyesight of the public, Dr. Goldsmith continued: "In the interests of saving both the

vision and the television of the public, only an experienced and responsible organization, such as the Radio Corporation of America, should be granted license to broadcast television material, for only such organizations can be depended upon to uphold high ideals of service." If these statements are universally accepted, all but the R. C. A. will quit the television field.

AMONG the suggestions made for increasing the number of local communities which may be represented in the ether by broadcasting effusions, came one from Senator Edwards of New Jersey to the effect that 25 channels be set aside for stations of 5000 watts power or more, leaving 52 channels for 500-watt stations and 12 channels for stations of 250 watts power shared with Canada. The average number of 500-watt stations which can be accommodated on a single channel is not higher than three, although there is a theoretical maximum of six, so that the Senator's plan provides for about 150 500-watt stations and for from 25 to 50 stations of greater power. The seemingly liberal plan therefore represents an even more drastic cut than that proposed by the engineers.

IN THE appointment of Louis G. Caldwell of Chicago as Chief Counsel for the Federal Radio Commission, and Dr. J. H. Dellinger, former Chief of the Radio Division of the Bureau of Standards, as Chief Engineer, the Commission has recruited to its ranks two of the most eminent and competent men in their respective lines. Caldwell, who is in no way related to his namesake, the Commissioner for the first district, has made a most exhaustive study of radio law and has represented important broadcasting interests. Dr. Dellinger's reputation as a scientist requires no rehearsal to any radio enthusiast. He has been a public servant for many years and, unlike most of those few qualified to act in an advisory capacity on technical matters to the Commission, has no former association which might be deemed a disqualification by radical persons.

THE Bell Telephone Laboratories demonstrated, on July 12, a new photoelectric cell which is considerably more sensitive than any similar device so far shown publicly. The original television transmitter and receiver, demonstrated over a year ago, were used in the newer demonstration, and by application of the more sensitive photoelectric cell, a full size figure in motion was successfully televised. The new cell greatly increases the range of vision of the eye of television and places even greater emphasis on the still unsolved problem of conserving the frequency or channel space required to transmit a television image of sufficient detail to have real entertainment value.

A NEW Japanese broadcasting station has been opened at Kumanoto of 10 kilowatts power, operating on 380 meters. The call letters are JOGK.

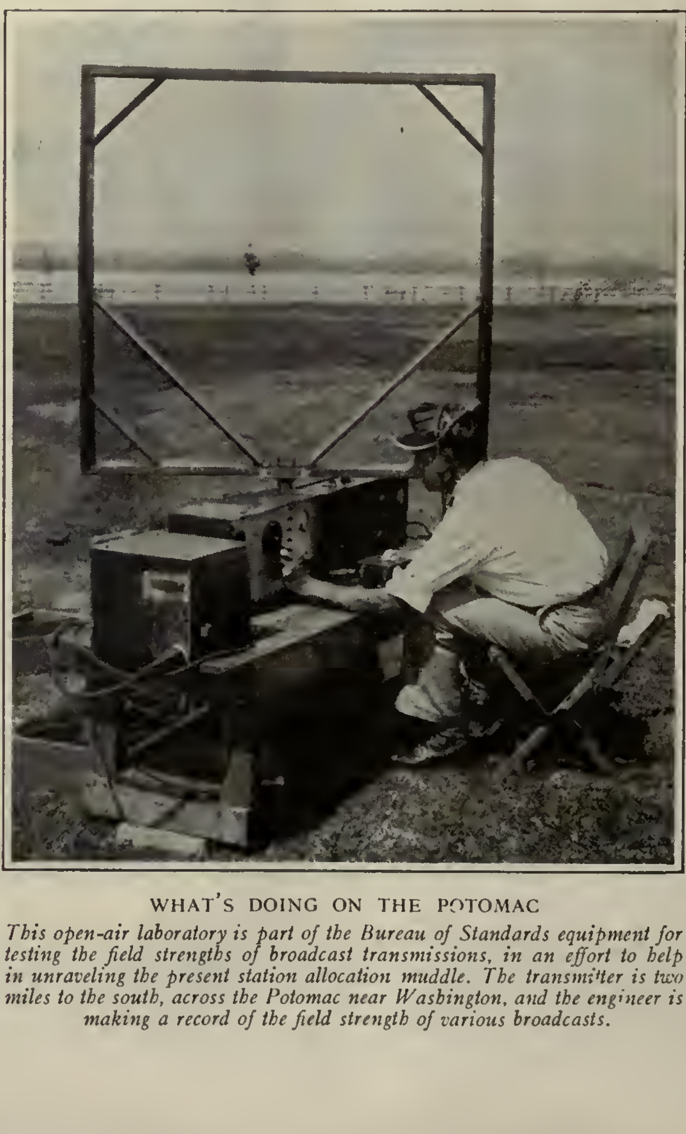
OUR commercial attaché in London reports that an American radio receiver, having five tubes, delivered at London at a cost of forty-five dollars, must then pay royalties of fifteen dollars to the Marconi Wireless Telegraph Company. These royalities tend to curtail American radio exports to England. American exports in 1926 to that country amounted to $55,375 in sets and $34,089 in tubes.

IMPROVEMENT in the naval communications system is indicated by the fact that the average time of messages between the Pacific Coast and the Philippines has been reduced to one hour and fourteen minutes in May, 1928, as compared with seven hours and five minutes, the average obtaining in June, 1926.

THE Radio Communications Board of the Philippines decided to issue licenses only to short-wave telegraph stations for remote districts where the services thereby established will not compete with that offered by the Bureau of Posts. Seven stations will soon be placed in operation by that body.

RECOGNITION of radio broadcasting as an agency for political propaganda has been accorded by the major political parties through the appointment of Joseph Israel II as radio director for the Democratic National Committee and O. P. Gascoigne to a similar office for the Republican National Committee.

BEGINNING with a single installation in June, 1925, the Lighthouse Service now has in operation twenty radio beacons along the shores of the Great Lakes. In fair weather, these stations transmit signals four times daily for a half hour, permitting the taking of compass readings. During heavy weather, they maintain a continuous compass service.



WHAT'S DOING ON THE POTOMAC

This open-air laboratory is part of the Bureau of Standards equipment for testing the field strengths of broadcast transmissions, in an effort to help in unraveling the present station allocation muddle. The transmitter is two miles to the south, across the Potomac near Washington, and the engineer is making a record of the field strength of various broadcasts.

A COMPANY has been formed in Sidney to take over the control of two local broadcasting stations which were suffering from lack of program variety and tendency to duplicate features. This is the first step in merging all Class A stations in a single system. It is said that only the state-controlled station at Queensland will remain outside the pale, if the plan of the new company is successful.

THE International News Service expects to exchange press reports with Europe from a station to be located at 59th Street in New York City. Reception will be conducted at Leafields, where re-transmission to all parts of Europe is possible. The United Press will not attempt to use radio in competition with existing communication systems, but will utilize its station at Garden City for expeditions, important broadcasts and similar special services.

AT A meeting of the International Circulation Managers Association, it was brought out that radio summaries of news features helped newspaper circulation, but that radio has cut the sales of extras on important scheduled events, such as prizefights and baseball games.

ONE million shares of Baird Television, Ltd., at five shillings a share, were subscribed to by the English public recently. These shares have risen in value upon circulation of a rumor that the American rights to Baird Television had been purchased. This public support of the issue appears surprising in the absence of any regular broadcasting of television images, and in the face of the hostile attitude of the British trade press, which issued an unanswered challenge to Baird to make a public demonstration of television by radio, posting a prize of five thousand dollars.

A Delaware charter has been filed by the American Baird Television Corporation with a capital stock of a million shares of no par value. No doubt the public will soon be invited to participate in this enterprise, possibly in advance of any demonstration of Baird equipment.

LICENSED broadcast listeners in Germany on April 1, 1928, totaled 2,234,732, as compared with but 2000 on January 1, 1924. The license fee paid by these numerous listeners amounts to fifty cents a month each and the government budget for the support of the nine broadcasting stations maintained in that country amounts to $12,500,000.

THE British Broadcasting Corporation showed a total income of $4,508,130 for 1927, of which about four million was from licenses and the balance from publications and other sources. Of this revenue, $2,438,640 was spent for program material. The system was on the air during the year for a total of 68,000 hours. There were 20 hours of breakdown. The number of listeners amounted to 2,395,174, an increase of 217,000 over the previous year. Apparently, the numbers of listeners in England and Germany are about equal, but three times as much money was spent in serving the German system as the British.

—E. H. F.

The Master Hi-Q Receiver in Its Cabinet

The "Hi-Q 29"—A Receiver with a Band-pass R. F. Amplifier

By D. K. ORAM

Hammarlund Mfg. Co.

OLD timers in the radio game who remember the difficulty in getting a lot of current into the antenna without the double humped resonance curves which usually resulted from their efforts may be shocked to learn that a use has been found for such broadly tuned circuits. Since Dr. F. K. Vreeland gave his paper on band selector circuits before the I. R. E. we have been waiting for the receiver that would put into practice such ideas, which consist briefly in making use of the "flat top" tuning effect of closely coupled tuned circuits or of the "staggering effect" of several circuits tuned to slightly different frequencies.

The present Master Hi-Q receivers employ two band-pass filters—that is, two circuits tuned to the same frequency and coupled together, with the result that the resonance curve is very flat over a range of frequencies controlled by the constants of the circuit and with very steep sides, so that unwanted stations have more than usual difficulty in making their presence heard.—THE EDITOR.

IN THE design of a modern broadcast receiver it is conceded that quality of reproduction and selectivity are of prime importance. Also, in most cases, a high degree of radio-frequency amplification is a distinct asset, if it can be secured without loss of stability and without affecting the preceding qualifications. A high-gain r.f. amplifier preceding the detector tube increases the sensitivity of the receiver as a whole. Great sensitivity is highly desirable from two standpoints. First, it enables the set owner to receive programs from very distant stations when he feels so inclined, and second, it makes possible quite satisfactory reception from local and moderately distant stations on a very short indoor antenna even in unfavorable locations.

Unfortunately, these three prime requisites of a fine receiver, quality of reproduction, selectivity, and sensitivity, are by no means independent of each other. For example, the modern high-quality audio transformers now available make possible the construction of a practically perfect audio amplifying system. If a power tube is used in the last stage of such an amplifier and its output fed into one of the better type speakers, the audio amplifying and reproducing system leaves little to be desired. However, this system can only amplify and reproduce what is fed into it by the detector tube, which in turn receives the signal from the radio-frequency amplifier. Hence it is evident that even a perfect audio system cannot provide a high quality output from the loud speaker if distortion is introduced in the r.f. amplifier due, let us say, to excessively sharp tuning, technically known as "side band cutting."

In the same way selectivity and sensitivity are incompatible. One of the reasons for this condition is not generally understood, and is even more seldom taken into consideration. The average receiver owner or experimenter bases his judgment almost entirely on the "apparent" selectivity. This is quite natural, in view of the fact that the actual selectivity of a receiver can only be determined by a series of very careful measurements. The apparent selectivity of the ordinary radio set decreases as its sensitivity increases. Therefore, of two receivers having exactly similar "actual" selectivity and one having, say, three times the sensitivity of the other, the set having the higher sensitivity (or amplification) will invariably seem broader or less selective. This principle is very clearly shown in Fig. 1. Curve A is the response curve of the less sensitive receiver when tuned to 600 kc. Assuming that no 600-kc. station is on the air at the time no sound will be heard from the loud speaker, as the sensitivity of the set is not great enough to bring the 580-kc. station (which is assumed to be on the air at the time) above audibility. Curve B represents the response characteristic of the more sensitive receiver, and under the above mentioned conditions the 580-kc. station will now be heard, since the increased amplification of the more sensitive receiver is sufficient to bring the signals above audibility. Thus it is quite easy to understand why the more sensitive of the two sets will appear to be less selective, although in reality one is equally as selective as the other.

THE ADVANTAGE OF THE SCREEN-GRID TUBE

THE new 222 type screen-grid tube with its high amplification factor and extremely low plate to grid capacity would at first glance seem to be ideal for use in r. f. amplifiers. The manufacturers of these tubes state that a voltage step-up of forty or more per stage is obtainable at broadcast frequencies. In addition the plate-to-grid capacity is said to be of the order of one-fortieth of a micromicrofarad or about one-four hundredth as great as that between the plate and grid of the 201A type tube. Therefore the appearance of the screen-grid tube, with a capacity so small that neutralization is unnecessary, was welcomed by set designers, and many circuits using them made their appearance. Many of these sets did have enormous amplification, making possible quite satisfactory reception on very short antennas. The selectivity of these sets, however, left much to be desired—so much so that the tube acquired the reputation of causing broad tuning.

In planning the set to be described the natural advantages of the screen-grid tube were carefully considered, and the various methods of overcoming the apparent disadvantages were also investigated. Two stages of r.f. amplification were decided upon as sufficient, as they could reasonably be expected to produce an overall voltage gain of more than one thousand. In order to achieve a high degree of selectivity with this amount of amplification some special form of tuning is necessary. The conventional antenna coupler and two interstage t. r. f. transformers were found to be wholly inadequate in the matter of selectivity, although the amplification was good. The tuned plate-impedance coupling condenser and grid leak arrangement specified by the manufacturers of the tube was passed up for the same reason. Calculation showed that it was quite feasible to tune both the grid and plate circuits of these screen-grid tubes. This is one of the marked advantages of this type of tube, since an attempt to tune both grid and

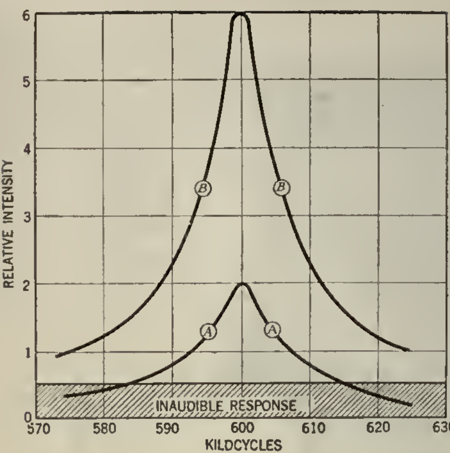


FIG. 1

plate circuits of an ordinary amplifier tube invariably results in uncontrollable self-oscillation. When both grid and plate circuits are tuned a two stage r.f. amplifier has a total of five tuned circuits, including the grid circuit of the first tube. This increased number of tuned circuits would naturally provide a marked increase in selectivity. In fact the scheme looked so good on paper that an experimental receiver was constructed embodying these ideas. The circuit diagram of the experimental model was substantially the same as that of the finished receiver shown in Fig. 5. On test, this model performed in a truly remarkable manner, greatly exceeding expectations. The r. f. gain was very good—enough to bring in many distant stations, including one on the Pacific Coast. The selectivity was such that more than a dozen distant stations were received while the local stations were operating. This test was made last May using a 75-foot antenna located in midtown New York.

THE COUPLING TRANSFORMERS

THE remarkable performance of this receiver can best be understood by consideration of the principles involved in its design. The interstage r.f. transformers are quite unique, in that they consist of two exactly similar coils. One constitutes the primary of the transformer and is connected in the plate circuit of the preceding tube, and the other coil acts as the secondary and is connected to the grid of the following tube. Each coil is tuned to resonance with the desired signal by means of a 0.00035-mfd. variable condenser. Due to the rather unusual mounting arrangement the mutual inductance or coupling between primary and secondary is very small. However, this does not mean that the energy transfer from primary to secondary is inefficient. On the contrary, when two tuned circuits are coupled to each other, the maximum secondary voltage is obtained when the relation $(2\pi f)^2M^2 = R_1R_2$ is satisfied, where f is the frequency to which both circuits are tuned, M is the mutual inductance in henrys, and R_1 and R_2 are the effective radio-frequency resistances of the primary and secondary, respectively. In the case of the coils used in the receiver under discussion the maximum secondary voltage is obtained with a coupling coefficient of the order of one per cent. The physical arrangement of the coils, as shown in Fig. 3, was chosen because it seemed the simplest way to secure such loose mechanical coupling while still keeping the coils close together, thus conserving space.

Due to the inherent characteristics of loosely coupled tuned circuits each of these doubly tuned r.f. transformers really constitutes a band pass filter. This is quite clearly shown in Fig. 2. In this figure is shown the tuning characteristic of one of these double-tuned loosely coupled transformers. The dotted line represents the response curve of one tuned circuit alone, and the solid line that of both circuits properly coupled. It will be noticed that the dotted curve of the single circuit is a typical resonance curve; very sharp on the top at exact resonance and sloping gradually toward zero as the frequency is increased or decreased. On the other hand the solid curve of the double circuit is quite broad and almost flat on the top over about seven kilocycles, but slopes more steeply on the sides and the response approaches zero much more rapidly above and below the resonant frequency. These curves in Fig. 2 are based on actual measurements of one of the new r.f. transformers used in the Hammarlund-Roberts "Hi-Q 29."

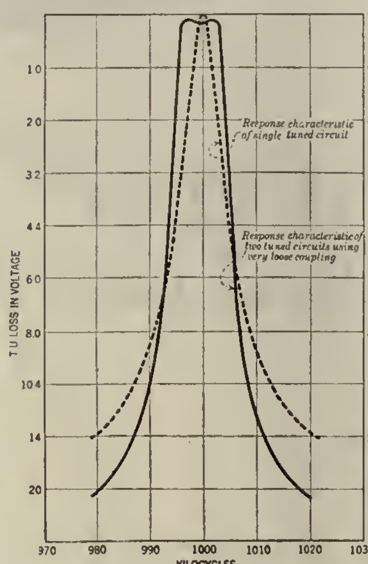


FIG. 2

While one of these double-tuned r.f. transformers provides an unusual degree of selectivity, the use of two such stages in cascade results in a vast improvement. As an illustration note that the response of an interfering signal at 20 kc. below resonance on the solid curve of Fig. 2 is but 9 per cent. or about $\frac{1}{11}$ of the response at the frequency for which the set is tuned. This is for one stage only. After going through the second stage, however, the intensity of this interfering signal will have been reduced to $\frac{8}{10}$ per cent., or about $\frac{1}{125}$. At the same time the addition of the second stage does not materially affect the shape of the top of the response curve. The top of the curve remains substantially the same as shown in Fig. 2; the sides become much steeper and the response approaches the zero line at a much more rapid rate.

[These percentages, when reduced to losses in TU, give interesting figures. At 20 kc. off resonance, for example, the discrimination of a single resonant circuit—using Mr. Oram's percentages—is 14 TU, while the doubly tuned circuit gives an additional 8 TU or a total loss of 22 TU. When these signals are passed through an additional doubly tuned circuit this becomes 44 TU, and if the antenna stage has a discrimination of 10 TU at 20 kc. the total selectivity factor becomes 54 TU, which is the difference between signals from two stations at an equal distance from the receiver but differing in power by a ratio of 250,000.—THE EDITOR]

The width and flatness of the top of the solid curve shown in Fig. 2 has an important bearing on the quality of the received speech and music. This is due to the fact that broadcast stations do not transmit on a single frequency, but rather on a band of frequencies. The width of the side bands varies somewhat, depending on the transmitter adjustments and also on the type of program being broadcast. They are, however, generally conceded to be about five kilocycles wide for high quality transmission. It is therefore apparent that the receiver should be capable of amplifying a *band* of frequencies with substantial uniformity if the program is to be received faithfully. Hence the desirability of the wide flat top on the overall response curve of a high-grade receiver. When the top of the response curve is sharp instead of flat all the frequencies in the band are not amplified equally. Consequently certain of these frequencies reach the detector much stronger than others with the result that even the most perfect a.f. amplifier and loud speaker will be unable to reproduce the program with its original quality.

The two double-tuned r.f. transformers used in the Hammarlund-Roberts Hi-Q 29 necessitate the use of four variable condensers—one to tune each of the four coils. Since all four of the tuned circuits are identical these four variable condensers are rotated by a common shaft actuated by a new model drum dial having a smooth positive drive without backlash. The tuned input circuit to the grid of the first screen-grid tube, often referred to as the antenna coupler, is of the conventional type having a tapped primary making it adaptable to different length antennas. The variable condenser tuning this antenna coupler is on a separate shaft and has a separate drum dial, thus enabling this circuit to be tuned to exact reasonance with the received signal.

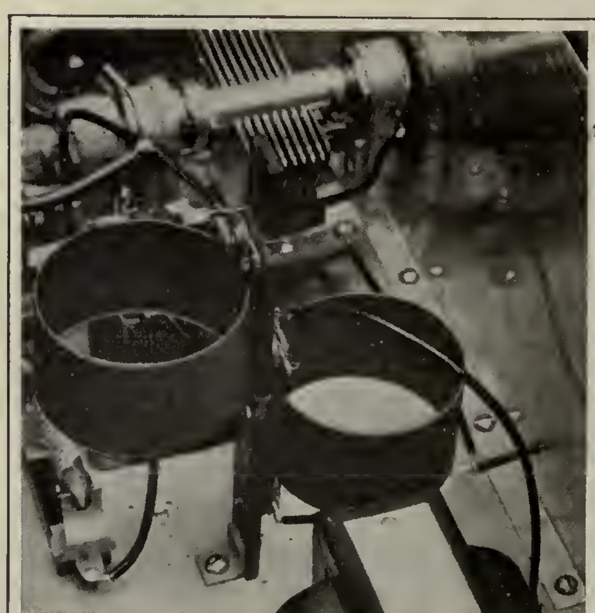


FIG. 3. AN R. F. COIL

Both primary and secondary of this interesting transformer are $1\frac{13}{16}''$ in diameter and $1\frac{1}{8}''$ long, wound with silk covered wire, about 80 turns of No. 28 wire being used. The detector input coil has a tap at about the twentieth turn from the grid end, as indicated in Fig. 5.

OTHER DESIGN FEATURES

THE volume control is quite out of the ordinary and is made possible only by the characteristics of the screen-grid tubes. It consists of a

100,000-ohm potentiometer, R_1, connected across the 45-volt B supply. The center tap of this potentiometer provides a variable voltage which is impressed on the screen grids of the two r.f. amplifier tubes. The amplification obtainable from these tubes varies within wide limits as the voltage on the screen grids is varied, being at maximum around 45 volts and dropping rapidly as the screen-grid potential is reduced. This provides a very smooth control of volume within wide limits without affecting quality or tuning in the slightest degree.

While the screen-grid tubes have a very low value of capacity between plate and grid, thus almost entirely obviating the tendency to feed-back through the tubes themselves, this advantage is nullified if feedback occurs in other parts of the receiver. Taking this into consideration, every effort has been made to isolate all circuits in which coupling might result in instability. The negative bias for the grids of the r.f. tubes is secured by the drop across individual 10-ohm resistors, R_6 and R_8 in series with the negative leg of each screen-grid tube filament. Since the screen grids of both these tubes are biased by the 100,000-ohm potentiometer, R_1, 5000-ohm isolating resistors, R_{10} and R_{11}, are inserted in the lead to each of the screen grids, which are in turn bypassed by means of separate 0.5-mfd. bypass condensers, C_8 and C_{10}. The plate circuits of these tubes are likewise isolated by individual filters consisting of separate radio-frequency choke coils, L_1 and L_2, and bypass condensers, C_9 and C_{11}. In addition to the above mentioned precautions the entire r. f. end of the receiver is thoroughly shielded. Each stage is entirely enclosed in a snug fitting aluminum box which is securely fastened to the metal chassis. The screen-grid tubes are so located that the leads to the control grids are as short as possible and well removed from the plate leads, which are also very short. By placing these tubes between the cans as shown in Fig. 4 the can sides are used also as tube shields, effectively preventing coupling between the tube elements and other parts of the circuit. This arrangement provides the minimum coupling between output and input circuits, which is extremely important.

The audio amplifier is of the conventional type consisting of two stages transformer coupled. The a.f. transformers, T_1 and T_2, have a very flat frequency characteristic over the usual a. f. range. An r.f. choke coil is placed between the plate of the detector tube and the first a.f. transformer to prevent any stray r. f. voltages from getting into the a. f. amplifier. A 171 type tube is recommended for use in the last stage, although other types may be used if suitable A, B and C voltages are available.

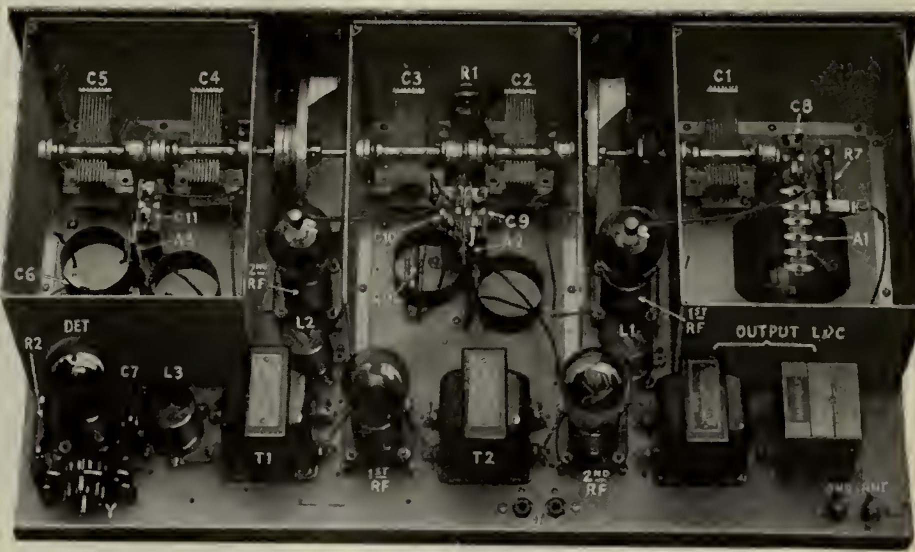


FIG. 4. HOW THE INSTRUMENTS ARE MOUNTED

A. C. OPERATION

ALTHOUGH the above description is based on the battery operated model, a complete all electric model has been developed. Arcturus a.c. screen-grid tubes are used and some slight changes in wiring are required. Otherwise the operating characteristics and set performance of the a.c. and d.c. models are identical. Constructional data on the a.c. model may be obtained from the kit manufacturers, or through RADIO BROADCAST. Fig. 4 is a top view of the a.c. set, which is similar in general appearance to the d.c. model.

LIST OF PARTS

THE parts used in the d.c. laboratory model of the Master Model "Hi-Q 29" receiver are listed below. The coil data is given in Fig. 3 in case it is desired to make these at home. All the other parts are of standard design, and substitution of other makes of equivalent parts may be made.

A_1, A_2, A_3—1 Hammarlund coil set, No. HQ-29
C_1 to C_5—5 Hammarlund midline condensers, 0.00035 mfd., No. ML-17
C_6—1 Sangamo fixed mica condenser, 0.00025 mfd.
C_7—1 Sangamo fixed mica condenser, 0.001 mfd.
C_8 to C_{11}—4 Parvolt bypass condensers, 0.5 mfd., series 200
J—1 Pair Yaxley insulated phone tip jacks, No. 422
L_1, L_2, L_3—3 Hammarlund radio-frequency chokes, No. RFC-85
R_1—1 Carter "Hi-Pot" potentiometer with switch, 100,000 ohms, No. 11-S
R_2—1 Durham Metallized resistor, 2 megohms
R_3, R_4, R_5—3 Amperites, No. 1-A
R_6, R_7, R_8, R_9—4 fixed filament resistors, 10 ohms (included in foundation unit)
R_{10}, R_{11}—2 fixed resistors, 5000 ohms (included in foundation unit)
T_1, T_2—2 Thordarson audio transformers, No. R-300
Y—1 Yaxley Cable Connector and Cable, No. 660
2 Hammarlund knob-control drum dials (walnut), No. SDW
5 Benjamin Cle-Ra-Tone sockets, No. 9040
2 Eby engraved binding posts
1 "Hi-Q 29 Master" foundation unit (panel, shields, chassis, shafts, binding post strips, clips, fixed resistance units R_6, R_7, R_8, R_9, R_{10} and R_{11}, resistor mounts, and all special hardware required to complete receiver.)

To place the set in operation the following apparatus is necessary.

2 CX-322 tubes
2 CX-301A tubes
1 CX-371A tube
Source of A, B, and C voltage (6 volts A, 45, 90, 135 volts B, $4\frac{1}{2}$ and 27 volts C)

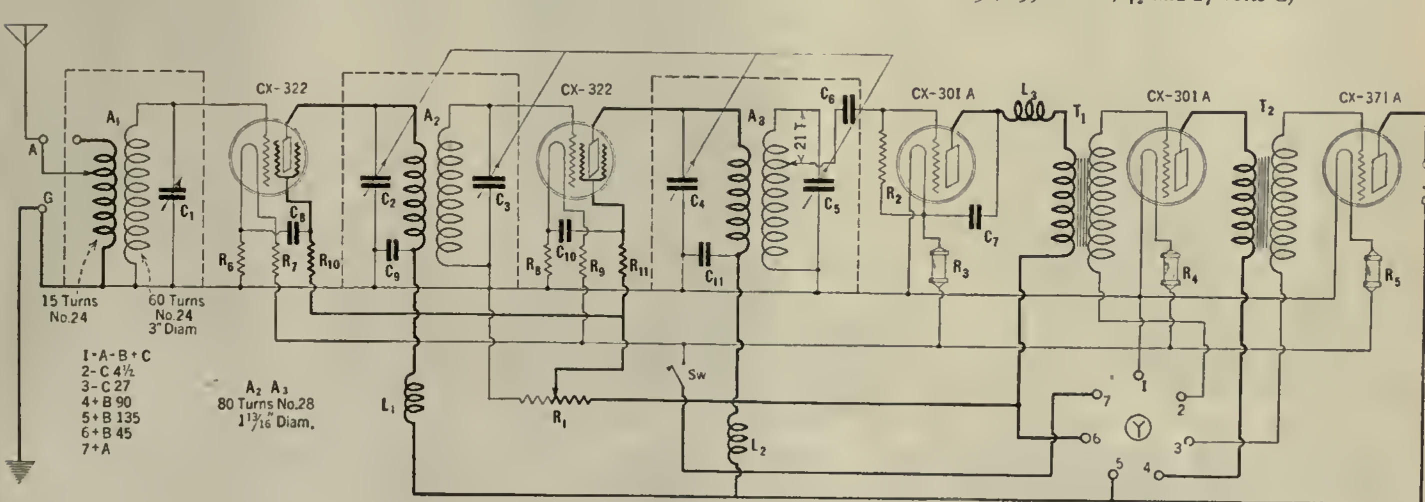
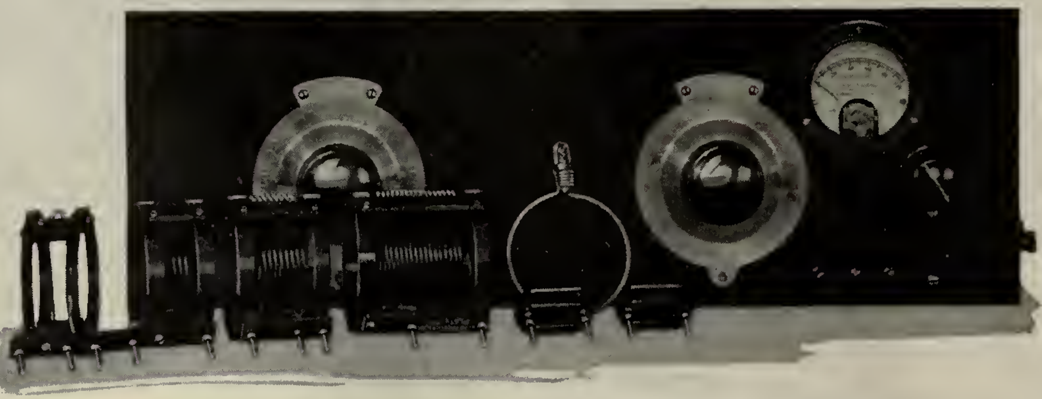


FIG. 5. THE CIRCUIT OF THE "HI-Q 29"

A Short-Wave Transmitter for 1929

By ROBERT S. KRUSE



THE COMPLETED TRANSMITTER

The transmitter is shown here with one set of plug-in coils and condensers (except the 10-meter coils, which are shown in Fig. 2) and with the small loop-and-lamp used testing the oscillator and amplifier circuit.

AMATEURS are a curious lot—years ago they should and could have had just such a 1929 transmitter as Mr. Kruse describes in this article, a transmitter that stays on the wavelength to which it is set, one which delivers a good note, and in which vagaries of antenna height or power supply are prevented from affecting the frequency of transmitted signals. The transmitter is an oscillator-amplifier set-up that can be put on the air "as is" or that can be used with an external r.f. amplifier employing bigger tubes. Or, as a later article will describe, the present apparatus can be modulated by voice and thereby provide rapid communication over medium distances.

—The Editor.

MY GOOD friend H. B. Richmond once said that it is good practice to discount warnings of radio troubles by 90 per cent. in most cases but by 100 per cent. if a complete disaster is announced.

The rule has worked well for four years. It happens that during those four years I have probably written or edited as many stories about American short-wave radio as anyone. For both reasons I have the utmost confidence in applying Mr. Richmond's entire 100 per cent. discount to the present predictions of the calamities that are to befall amateur radio transmission when the bands are narrowed on January 1, 1929.

There is absolutely nothing to these dangers except state of mind. No legal lightning will strike the transmitting antenna; no one will be arrested for owning a microphone; no startling new apparatus will be needed.

A set not good enough for 1929 was certainly never good enough for 1928; therefore, the set to be described is no more of one year than of the other. Furthermore it is in no way revolutionary except in being so laid out as to permit the use of all of the "practical" bands. Incredible as it may seem, such sets seem not yet to have been built, although their design involves nothing new.

THE "PRACTICAL" BANDS

IT IS necessary at the beginning to gain some understanding of the importance of breaking away from the vicious habit of "choosing a wavelength" or a pair of wavelengths, building a transmitter for them, and then settling down until removed by force. The active experimenter is not quite as guilty of this practice as the more stationary "message handler." Unfortunately the beginner is very likely to hear the latter (who is constantly on the air) and to follow him into the unhappy scramble on 40 and 80 meters. As a result howling bedlam exists in those bands and its occupants are sure they cannot spare even one kilocycle from either band, whereas 1929 will cut the 40-meter band from 1000 to 300 kilocycles.

The present situation in the amateur bands, with respect to wavelength allocations, is summed up in Table I, on this page.

Analyzing this table, it seems at first that the available space has been reduced from 15,000 kc. to 7485 kc., and the amateur deprived of half his territory. However, of the 15,000 kc. available to the amateur in 1928, the bands actually used were only 4000 kc., and this includes the almost uninhabited 150–200 meter band. The wavelengths below 10 meters were vacant—some 11,000 kc. of ether space. Now for 1929 the available space on the 10, 20, 40, 80, and 180 meter bands amounts to 3485 kc., and this does not include some 4000 kc. on the 5-meter band which is crying for development.

We see at once that the saddest possible way of looking at the thing is that we will drop from 4000 to 3485 kilocycles. Somehow that outlook fails to depress me. It seems as if the beginner will find quite as much room as before, while the present station owner has but to bring his equipment up to the requirements of a year ago in order to be perfectly ready for 1929.

TABLE I

AMATEUR CHANNEL ALLOTMENTS

1928		1929	
Width in kc.	*Wavelength in meters*	*Width in kc.*	*Wavelength in meters*
500*	150—200	285†	175—200
500*	75—85.7	500†	75—85.7
1000*	37.5—42.8	300†	41.1—42.8
2000*	18.7—21.4	400†	20.8—21.4
2000	9.99—10.7	2000†	10.0—10.7
8000	4.69—5.35	4000	5.0—5.4
1000	0.7477—0.7496		Below 5 not reserved
4000 kc. used now		3485 kc. practical	

*Bands used in 1928. †Bands practicable in 1929.

PRELIMINARIES

THE discussion and the table will have made clear that we should have a set and an antenna capable of operating at a variety of wavelengths. Having set the transmitter squarely on one of those wavelengths we are ready to begin telephone or telegraph transmission with the certainty of reaching someone.

The beginning of the whole business is this ability to set to a known wavelength with a transmitter which will thereafter stay on that wavelength. Since we propose to work in 5 and possibly 6 bands it would be very expensive, complex and time-consuming to do this thing with crystal control, nor is that necessary if a suitable wavemeter is *permanently* stationed alongside the transmitter.

It is perfectly possible to build a suitable wavemeter, but it is a difficult job even for the experienced experimenter who is assisted by calibration from a quartz crystal or else some new standard frequency schedules from our good friends of the Gold Medal Station wcco-9xl-9wi. It is much more satisfactory to purchase an "amateur band wavemeter."

While the wavemeter is coming we have time to explain to the newcomer in transmitting what is required in the way of licenses. Two licenses are required, both being issued by the Federal Radio Commission through the various Supervisors of Radio under Mr. W. D. Terrell, Chief of the Radio Division of the Department of Commerce. The first license to be obtained is the amateur operator's license. One should accordingly write to the Supervisor of Radio for the particular district in which one lives and request information as to the manner of obtaining the operator's license.

The papers received in reply will explain how the operator's license is obtained and at that or a future time one is advised as to the station license which will state the station call and also the wavelengths at which it may operate. None of the examinations are hard, nor need any fear be felt with regard to the test on code reception, since the necessary skill can be acquired at odd times by listening to short-wave stations and ships with a plug-in coil receiver. If there is any hurry the thing can be done more rapidly by a

week or ten days of tutoring with an operator and a buzzer. It is well if the tutor is very steady, and rather undesirable if he is fast, or thinks he is.

THE QUESTION OF POWER SUPPLY

HAVING done with rumors and law we may now get down to radio. There is space in this article neither for the fundamentals of transmission nor for a technical display of equations and curves, and the reader may therefore assume the evil preliminaries to have been completed before his arrival. The circuit of the transmitter is shown in Fig. 1, and is a simple variation of the Colpitts oscillator which permits placing fairly large capacity across each of the tube capacities whose variations ordinarily cause wavelength changes. Even with such a circuit the greatest steadiness is not obtained unless it is protected from the variations of the antenna system and from changes in filament and plate voltage. The antenna variations can be kept from the oscillator (to a very large degree) by interposing a stage of neutralized r.f. amplification; our set accordingly consists of a receiving tube used as an oscillator with a somewhat larger tube acting as amplifier. That idea is, of course, very far from new and has during the last few years been carried out in many forms.

To avoid the effects of voltage variation, the use of the oxide filament type of tube represented by the UX-112, or the UX-201A tube with the thoriated filament, is recommended. Both of these tubes can stand slight variations in filament voltage without much effect on frequency. These are used where storage battery filament supply is used for the oscillator, which is, of course, desirable for the greatest steadiness. Since a storage battery is more or less of a nuisance one may wish to use alternating current filament supply. A wide variety of tubes have been tried on a.c. supply by the author, and *very much* the best, when both steadiness and life are considered, have been the Arcturus Type 28 and Type 30. Please understand that I am not criticizing other small tubes, which are doubtless perfectly good for their normal purposes.

The oscillator plate supply is obtained from a 180-volt battery of dry cells, which can be of the size represented by the Burgess type 2308, or of the larger size. This practice was first hauled out of the laboratory and into transmission practice by Mr. Willis Hoffman of the Burgess Laboratories. (NOTE: A special heavy-duty 108-volt unit cataloged PL-5728 has just been put on the market by Burgess for this purpose.) By providing a very steady oscillator these devices start the whole set off in the right direction.

THE CIRCUIT LAYOUT

THE oscillator may be a 201A, 112, 112A, Arcturus Type 28, or even 226 tube. The amplifier may be a 112, 171, 210, 250, or Arcturus Type 30 tube. Consequently rheostats have been omitted entirely in the diagram and discussions and are to be supplied externally or else built in when the builder has found his pet tube combination. The set as it stands is meant for a 201A, 112, or Arcturus Type 28 tube in the oscillator socket and a 112, 171, or Arcturus Type 30 tube in the amplifier socket. It has, however, been run with a 112 in the first socket and a 210 or 250 tube in the second socket. The operation was satisfactory, but the stopping condenser, C_5 in Fig. 1, in the amplifier plate circuit becomes rather warm at voltages above 300. For regular operation with the 210 or 250 as amplifiers it should be replaced by a Sangamo 1000-volt type. With these changes the amplifier plate voltage may be carried as high as 600, provided that a similar change is made in the plug-in loading condensers for the amplifier.

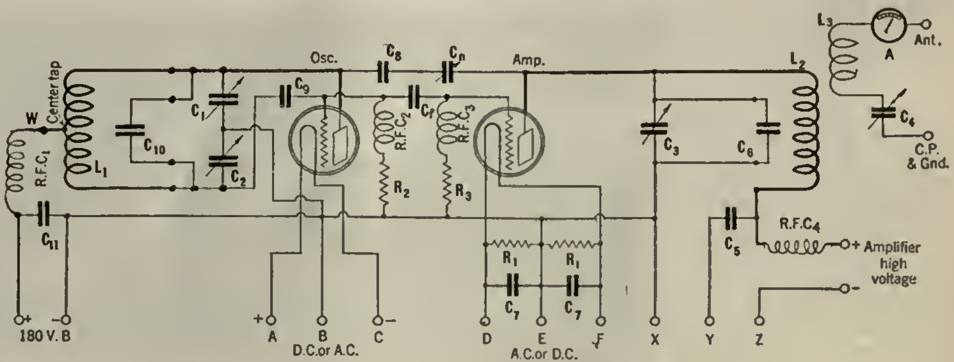
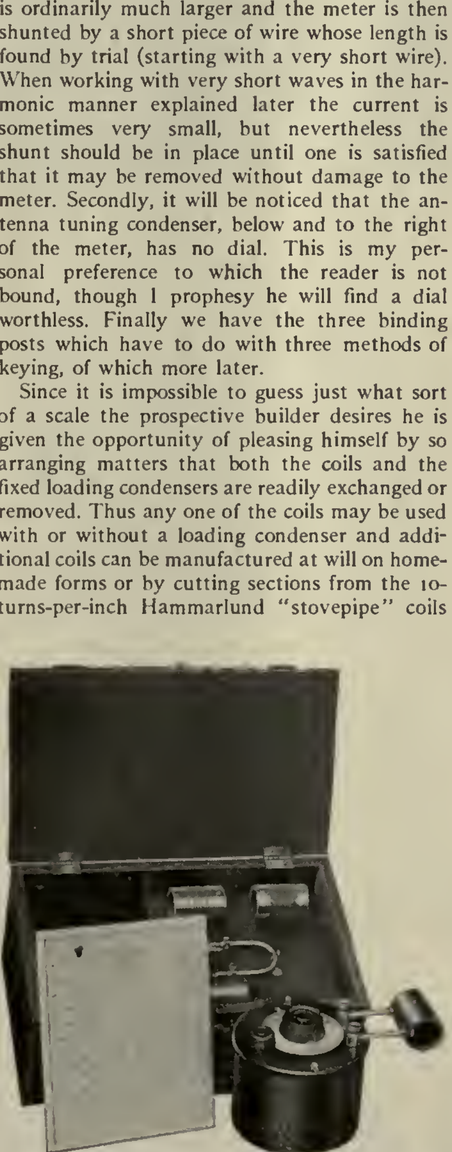


FIG I. THE SCHEMATIC DIAGRAM

It will be noticed from the photograph at the begining of this article that the panel shows three peculiarities which may as well be explained now. The antenna meter is a Weston thermo-galvanometer of the well-known model 425 which gives full scale reading with a current of 115 milliamperes. The antenna current is ordinarily much larger and the meter is then shunted by a short piece of wire whose length is found by trial (starting with a very short wire). When working with very short waves in the harmonic manner explained later the current is sometimes very small, but nevertheless the shunt should be in place until one is satisfied that it may be removed without damage to the meter. Secondly, it will be noticed that the antenna tuning condenser, below and to the right of the meter, has no dial. This is my personal preference to which the reader is not bound, though I prophesy he will find a dial worthless. Finally we have the three binding posts which have to do with three methods of keying, of which more later.

Since it is impossible to guess just what sort of a scale the prospective builder desires he is given the opportunity of pleasing himself by so arranging matters that both the coils and the fixed loading condensers are readily exchanged or removed. Thus any one of the coils may be used with or without a loading condenser and additional coils can be manufactured at will on home-made forms or by cutting sections from the 10-turns-per-inch Hammarlund "stovepipe" coils and equipping them with the same General Radio spring plugs with which those shown are furnished. The coils to be used in the oscillator are center-tapped, the center-tap being brought to a third spring plug for which a socket is added in the oscillator coil mounting. To permit all coils to be used in any position an extra hole is drilled in the amplifier coil mounting to accommodate this plug.



THE GENERAL RADIO WAVEMETER

The wavemeter has coils to cover all the amateur wave bands. The small U-shaped coil in the box is for the 5-meter band

Table 2 shows how all the standard bands can be reached with a set of Aero transmitting coils plus a pair of single-turn copper strip coils such as are shown in Fig. 2 for the 10 meter band. The coils illustrated are about $3\frac{1}{2}''$ in diameter. They are made of strip about $\frac{1}{32}''$ thick and $\frac{3}{8}''$ wide. All the bands are well spread out on the dial and will be quite O. K. for 1929, especially as the dials can be read to one part in 1000.

On the 10-meter band it is advantageous to use heavy wire or strip in the tuned circuits, not to reduce resistance but to have less inductance in the leads and therefore a bit more in the coil.

It will be noticed that no arrangement has been made for changing the amount of power fed from the oscillator to the amplifier except by making changes in the size of the feed condenser, C_f. Taps on the coil L_1 are a nuisance and are therefore avoided. This does not mean that C_f should be tinkered with after the right adjustment for a given amplifier tube has been found. On the contrary it should be left severely alone thereafter since changes in it will shift the wavelength calibration, which is not serious but rather confusing. C_f may be a small variable condenser but this is not recommended for the reason just mentioned; if a change is really needed the screw terminals of the Sangamo condenser always permit it. A capacity of 50 or 100 mmfd. will meet all needs. For the 210 as amplifier the larger capacity is recommended.

OPERATION

FOR its normal operation the set needs only one meter which is placed in the antenna circuit. One must admit that it would be somewhat more convenient to operate the set during the first few days if at least one more meter were available. However, the receiving set will serve the same purpose, though a bit less conveniently.

Everything being assembled and the filaments lighting satisfactorily, one should begin by removing the amplifier tube and making sure that the oscillator tube does really oscillate. This can be done by listening with the receiving set and tuning either the transmitter or the receiver slowly. They should not be too close together nor should the antenna be connected to either one. If the signal is not found in this way a milliammeter or a pair of phones may be put into the plate supply lead at the point marked W in Fig. 1 and the tuning process repeated. At resonance a click in the phones or a jump of the

meter will be encountered. The phones are to be preferred since with them the observer can recognize the familiar sound occasioned by an oscillating tube. Do not leave the phones in the plate circuit long, even with a 201A, and do not use them at all with larger tubes. Fortunately, such oscillators usually work promptly. If any doubt remains it may be removed with a very simple device consisting of a small flashlamp or a panel light to the terminals of which is soldered a single turn of wire about 3″ in diameter. This is hung on the end of the oscillator coil, L_1, and will usually light promptly unless the lamp is too large or too closely coupled to the coil, L_1. If no light can be obtained with any of the various coils in place everything should be gone over carefully and as a final resort a different grid leak may be tried.

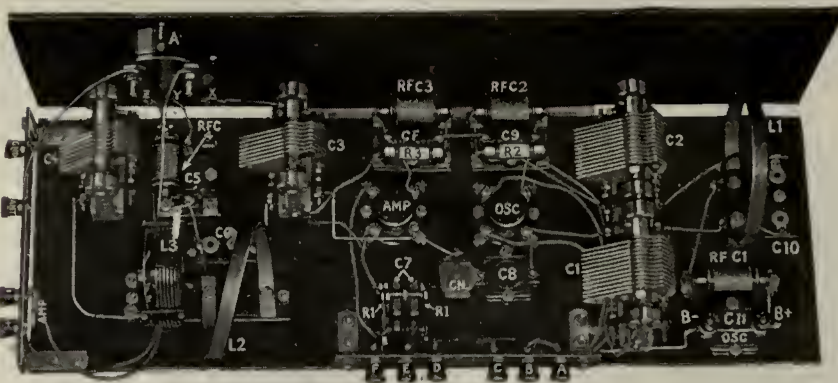


FIG. 2. THE LAYOUT OF PARTS

The coils, L_1 and L_2, are the special coils used for covering the 10-meter band. They are described in the text. Only the plug-in mounts for the oscillator and amplifier loading condensers, C_{10} and C_6 are shown in this picture

Since the r.f. amplifier is very much like those used in reception it has the same troublesome habit of wanting to go into oscillation.

To make sure of this point one removes the lamp-and-loop from L_1 and hangs it on the end of L_2, after which the oscillator is started but the amplifier plate supply is left off, although it is best to light the amplifier filament. By careful tuning of C_3 it should be possible to cause the lamp to light in the new position. Since the absence of plate supply for the amplifier prevents amplification it is clear that the power is being fed through from the oscillator by capacity effect between the plate and grid of the amplifier tube. This can be neutralized by adjustment of C_n until the lamp is out. The adjustment must be made without bringing the hand near Cn, which calls for some sort of a wooden screwdriver whittled from a dowel or the like. The lamp will probably go out over quite a wide range of C_n. The condenser should accordingly be set in the middle of this space. It is best to repeat the adjustment with several coils and with different settings of C_1, C_2 and C_3 to obtain the best average adjustment.

A SIMPLE ANTENNA SYSTEM

HAVING an oscillator and amplifier in operation, one is ready for the antenna. There is a general belief that to work on five or six wavebands it is necessary to have as many different antennas. Fortunately this is not correct, and a single antenna system of normal dimensions will give a good account of itself on 5, 10, 20, 40, 80 and 180 meters.

An antenna system can be made to oscillate electrically at a variety of frequences without the necessity of changing its length each time. Thus if we desire to work at 40 meters we need not have an antenna which is "just made" for that wavelength, but can just as well use one which tunes to 120 meters naturally. The third harmonic of this wavelength is 40 meters on which we desire to work.

This is exactly what is to be used with this set—a regular broadcast receiving antenna about 100 feet long from the end of the lead-in to the tip end of antenna. In addition a 75-foot counterpoise will be necessary and a good ground connection. When on the 180-meter band the antenna and counterpoise wires are connected together at the point of connection to the antenna coil L_3, and a ground is attached to the ground post. In addition a small loading coil may be necessary. On the other amateur bands the ground is not used and the counterpoise is attached to the ground post, the antenna to its proper post, and the loading coil not used at all.

The antenna should be 20 feet or more above ground and may be as high as 60 feet. The counterpoise wire should be not closer than 6 feet to ground or any other solid material.

The practical method of getting the transmitter on the air is to tune the oscillator to the desired wavelength by means of the wavemeter, then to tune the amplifier to that same wavelength, as shown by the best response of the wavemeter when placed at that end of the set, and finally to adjust the antenna tuning system so that current shows on the antenna meter.

The movable antenna coil, L_3, is not a device for obtaining the largest possible antenna current, which, as a matter of fact, does not give as good performance as does a slightly smaller antenna current. A rough general rule is to start with the coil L_3 at about 45 degrees and after the largest possible antenna current is obtained by adjustment of the various tuning condensers this coil may be tilted back to a position giving about 80 per cent. of the largest current.

No rule is good in transmitter adjustment until one has checked the result by listening with an oscillating receiver. This should be done without a receiving antenna, and the receiver should not be in the same room with the transmitter. In most cases it will be found that it is preferable to detune the antenna slightly, rather than to secure the 20 per cent. drop entirely by tilting of L_3. An adjustment that is satisfactory on a fair day may not answer through wind and rain. On the first bad day the whole series of adjustments should be checked.

In order to make precise adjustment and reading practical the set is given dials which not only have a smooth slow-motion mechanism (generally miscalled a "vernier") but in addition have a true vernier scale which permits reading to one tenth of one division of the dial scale.

TABLE 2

Band (Meters)	*Osc. Coil*	*Amp. Coil*
10	1 turn special	1 turn special
20	3 turn standard	3 turn standard
40	3 turn standard +C	3 turn standard +C
40	8 turn standard	8 turn standard
80	8 turn standard +C	8 turn standard +C
180	16 turn standard +C	17 turn standard +C

C = 0.00025-*mfd. plug-in condenser.*

MICROPHONE AND KEY

FOR several years there has been a rather tiresome controversy as to the desirability of the microphone and voice against the key and code. It is somewhat hard to see why a controversy is necessary, since both schemes have advantages and disadvantages which every man should be free to weigh for himself. Briefly the phone is rapid but has a relatively short reliable range, whereas the key makes up for its slowness by a very materially greater range and a superior ability to work through interference and static. This at once suggests the use of phone on those waves which are most reliable over limited distances and the use of the key for longer distance work. There is, however, no reason for being arbitrary about it and I personally feel that an unfairness was committed in recommending the removal of phone from the 20-meter band and its restriction to the top pair of bands, which in effect restricts it to local and semi-local work.

It will be seen that the various factors interlock so that unavoidably one must consider the question of modulation as a whole, including both the key method and the voice method. This will be done in a future article. For the present, however, the transmitter can be put on the air by strapping X and Y (Fig. 1) and keying between them and Z or by strapping Y and Z and keying between them and X. Short key leads are advisable.

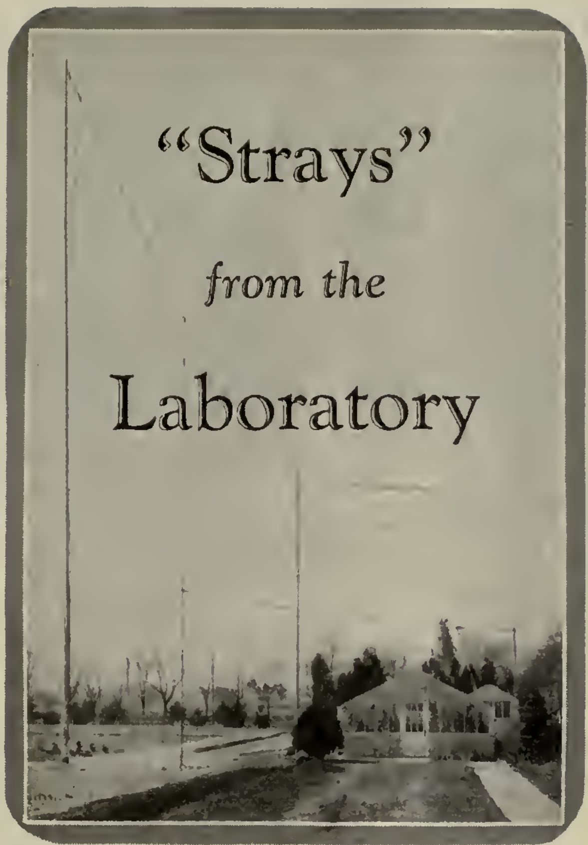
LIST OF PARTS

The parts used in the model of the transmitter illustrated are as follows:

A—1 Antenna meter. Any 0–1 ampere type or Weston model 425 thermo-galvanometer with shunts
C_1, C_2—2 National Equitune condensers, 0.00025 mfd., ganged on same shaft
C_3, C_4—2 National Equitune condensers, 0.00025 mfd.
C_5—1 Bypass condenser, 0.01 mfd. (see text, p. 345.)
C_6—1 Sangamo mica loading condenser equipped with General Radio spring plugs, 0.00025 mfd.
C_7—2 Filament bypass condensers, 0.006 mfd.
C_8—1 Fixed condenser, 0.005 mfd.
C_9—1 Oscillator grid condenser, 0.0002 mfd.
C_{10}—1 Sangamo oscillator loading condenser, 0.00025 mfd. See note on C_6.
C_{11}—1 B-battery bypass condenser, 0.01 mfd.
C_f—1 Feed condenser, 0.0001 mfd.
C_n—1 Hammarlund neutralizing condenser
L_1, L_2—1 Set of plug-in coils as described in Table 2.
L_3—1 Aero hinged antenna coil
R_1—2 Carter center-tap resistors, 15 ohms
R_2, R_3—2 Tobe Veritas grid leaks, 7500 ohms
RFC_1, RFC_2, RFC_3, RFC_4—4 National type 90 Universal chokes
ABC—Oscillator filament supply posts
  For d.c. connect B & C
  For a.c. leave B blank, connect A to D and C to F
DEF—Amplifier filament supply posts
XYZ—Control posts. Use for phone and telegraphy
2 National Vernier dials
2 General Radio sockets, type 349
Composition front panel, 7″ x 21″
Composition base board, 8″ x 21″

The tubes which may be used and the power supply are discussed in the text.

"Strays" from the Laboratory



Two Interesting Patents

TWO American patents which should interest technical readers are quoted and illustrated in *Radio* (Berlin) for July, 1928. The first (No. 693,646) is shown in Fig. 1, slightly redrawn, and was issued to Fritz W. Falck of Los Angeles. It is composed of a system to prevent distortion due to core saturation in an audio amplifier. The idea is to use two transformers as shown and to divide the load so that either transformer will be adequate to "separately handle the current without distortion."

The second patent (No. 148,975) given mention in the July issue of *Radio* (Berlin) has been granted to a well known worker in radio fields, Dr. Lewis M. Hull, and consists of a two-grid tube circuit, the second grid being used in connection with an external inductance to impress upon the second grid "a compensating voltage of proper phase and amplitude to oppose feedback currents flowing through the capacities of the tube between anode and control grid."

The diagram in Fig. 1 illustrates Doctor Hull's scheme. It has been seen many times within the last year in foreign periodicals, which have done considerably more with multi-grid tubes than has been done in the United States. Technicians will see the purpose of the extra grid and the coupling coil—to do away with the necessity of neutralizing the grid-plate capacity of the tube.

Such a circuit cannot be used with our screen-grid tubes since they have been designed with an entirely different purpose in mind, i. e., to decrease the inherent grid-plate capacity to such a low figure that danger from unwanted oscillations is minimized.

Radio as a Scapegoat

IT HAS become necessary for the Royal Meteorological Office to answer the many people of England who feel that broadcasting has something to do with weather. The prevalence of bad weather in England has been laid to the influence of the radio signals which of course cover that land, and in spite of the loud "no" which the Royal Meteorological Office answers to such ideas, it is probable that people will go on blaming the radio for everything that seems out of season or out of keeping with their plans and pleasures.

It is difficult for people to believe that radio is something that falls under the laws of nature, just as automobiles or flat irons do. Not a week passes by but what some doctor, or lawyer, or teacher, who ought to know better, approaches us with some argument like this: "Now, I don't know anything technically about radio, but wouldn't this be a good idea?" and then he launches forth on some impossible or already old scheme. The fact that the laws of transmission and reception are well known, and that methods of attaching coils, condensers and tubes together are already printed in books, never causes the would-be radio inventors a moment's pause. And when some engineer tells them that their scheme is not worth wasting time on, they always feel he is liable to steal the idea and hasten for this reason to find another and less trained ear for their schemes.

A Screen-Grid Mystery

SERVICE men often run into strange and interesting problems. Suppose you were called out to look at a screen-grid tube receiver which seemed pretty "dead" although all of the tubes burned with normal brilliancy, voltages were correct, there were no opens or shorts, etc? Would you finally trace the trouble to lacquer on the small metal cap on top of one of the screen-grid tubes and to which a wire should normally have made an electrical connection? A case of this sort came to our attention recently; once the lacquer was scraped off and proper electrical connection made, the receiver, needless to state, came to life.

Mortality Among the A. C. Tubes

THE rapidity with which such tubes as the 171's burn out when their filaments are operated from a.c. may give a clue to the real reason why a.c. tubes seem to be shorter lived than battery tubes. The fault is not with the tubes, it lies with poor power line regulation. At times the line voltage is high, and naturally the filament voltage is high. Some tubes decrease in life by 50 per cent. when the voltage across the filament increases ten per cent.

Mr. A. O. Viereck, of Springfield, Mass., states that 171 tubes lasted less than 100 hours for him until he hit upon the plan of placing a resistance in series with the filament, and turning it so that the filament was just bright enough to prevent distortion. At the time of writing the letter his 171 "still was going strong," although it had been in use for over two months.

A still better remedy, of course, is to put a resistance in the 110-volt line which feeds the receiver. This may be set so that the voltage to the power equipment is below the point where too frequent tube replacement becomes necessary due to overloaded filaments.

Few people realize that considerable power must be dissipated within the tube and that overloading its filament or plate circuits is vastly more important, economically, than overloading its grid with a.c. voltages. A ten per cent. increase in line voltage produces a 20 per cent. increase in power used up in the filament and an equal increase in power required by the plate circuit. The filament must bear the brunt of all this increase, and unfortunately it does not have the margin of safety that is found in a machine rated in kilowatts.

Engineers as Salesmen

NOT long ago we read with considerable interest the statement of the head of a well known eastern university that the average salary of the graduates of this institution of the class, let us say, of 1910, is kept down to a rather low figure by the salaries of men now engaged in teaching, those in government service and those who are engineers.

It is only too true that engineering as a profession does not pay so well as selling bonds, or real estate, or selling anything, for that matter. However, it is encouraging to note from time to time the increasing appreciation for the work of the engineer and the laboratorician. The following statement comes from a vice-president of one of the largest banking institutions in New York City and is quoted from *Science*, April 27, 1928:

"When any New York banker is called upon to finance any corporation or business, especially one based directly or indirectly upon scientific pursuits, the first investigation made is in regard to the attitude of the institution toward the advancement of scientific knowledge. If there is maintained a scientific laboratory with a generous regard for the advances in pure science, the security is, to that extent, considered good. But if no attempt is being made to keep up with, or a little in advance of, the developments in science, then no considerable loan will be risked upon such a venture. Permanent business success is too intimately linked with scientific attainment to make any other attitude safe."

We chatted recently with the executive of a radio company whose name is everywhere a synonym for quality, for honest dealing and for the genial friendliness of its personnel. This organization is making changes in its methods of merchandising which will practically eliminate its present selling organization—the non-technical salesmen, who as far as salaries go rate much higher, in general, than engineers.

"We have found," stated this executive, "that our best salesmen are our engineers. They know

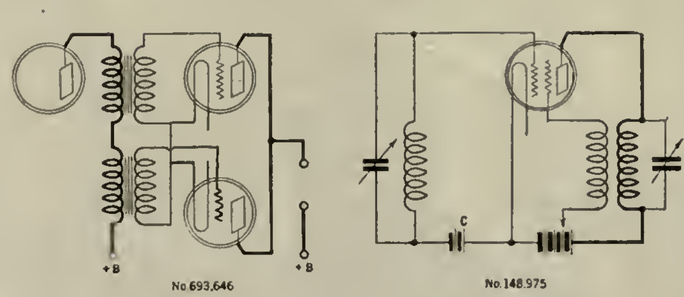


FIG. 1

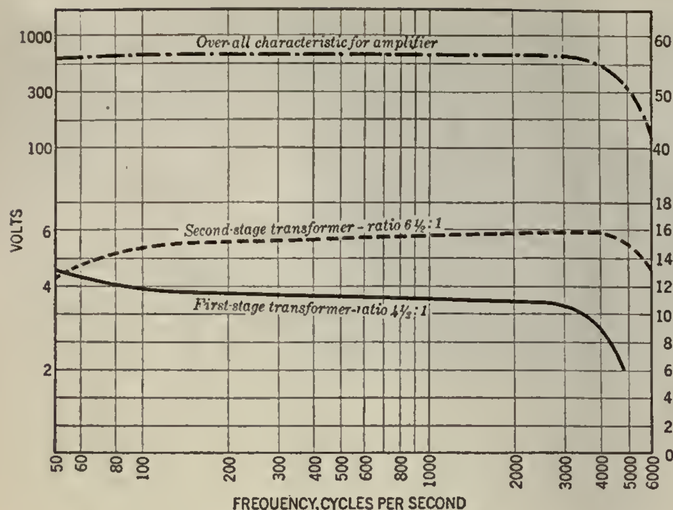


FIG. 2. FREQUENCY CHARACTERISTIC OF THE REMLER AUDIO SYSTEM

what they are talking about, what the organization they are "selling" needs; they can get into laboratories where no salesman would get even a pleasant look. They talk on equal terms with the chief engineer or director of research of the greatest organizations. Not one of our engineers goes out in the field who does not return with an armful of orders."

The Arcturus Radio company has recently decided to employ graduate engineers in their sales department. Mr. L. P. Naylor, Sales Manager, says:

"We need them on the road quite as much as in the lab. A. C. tubes are in a way a highly technical development—as well as something new. Reactionary dealers often bring up specious arguments against their use which can be answered authoritatively only by an engineer. And besides, the logical mind of the technically trained man is psychologically well grounded for sound salesmanship."

And so it looks as though the engineer may come into his own after all. Our idea of a good way for a young man to divide his time in college is to spend about three years in engineering school and three years in business school. He could then get a job selling bonds for the technical apparatus he, as an engineer, has designed.

We gloat over Mr. Naylor's final words, "the logical mind of the technically trained man is psychologically well grounded, etc." They may help to tide us over those bad moments when our classmate of the class of so-and-so, who sells real estate, invites us for a ride in the park in his new Packard.

Testing for Soft Tubes

THE following quotation from a letter from Professor Frederick Emmons Terman, of Stanford University, relates to our recent request for methods of testing for soft tubes:

Tubes which contain gas, popularly called soft tubes, can be detected with the circuit shown in Fig. 3. The test is made by touching lead *a* to the grid lead as shown, thus short-circuiting the grid leak. If a click is produced in the phones the tube is soft. Absence of a click indicates a hard tube.

The test described is based on the fact that in gaseous tubes there is some ionization produced in the tube even at low and moderate plate potentials. The ionization is caused by electrons striking the gas molecules and breaking them in pieces, some of which are positive (ions) and some negative (electrons). The positive ions are attracted by the negative grid, causing a grid current to flow through the grid leak. Short-circuiting the grid leak alters the grid potential by eliminating the voltage drop of the grid current in the grid leak, thus causing a change of plate current, and a click in the phones. When there is no gas in the tube, no positive ions are produced, and as electrons will not flow to the negative grid, there is no grid current, no voltage drop in the grid leak due to grid current, and hence no click in the phones on shorting the leak.

In carrying out the test a leak of at least a megohm should be used. It is also desirable to use a rather negative C battery, such as three or more volts. Soft tubes, such as the 200A, will draw a considerable electron current at grid voltages of one or two negative, and upon increasing the C bias the grid current goes through zero and changes direction, being positive ion current beyond about 2½ volts. To make certain a suspected tube is soft, it is desirable to test it at two grid voltages to insure that the reversal point of zero grid current is avoided.

With 45 volts on the plate and minus 3 volts on the grid, a 201A tube gives substantially no click, while a 200A tube, which contains much more gas, produces quite a thump.

Short-Wave Reception

OUR ONLY comment to this letter lifted from *World Radio* (England) is that Mr. Bell either has a magnificent DX receiver or a grand location.

I should like to report on short-wave reception in America. As everyone knows, short waves are no good over short distances. Consequently, reception of U. S. stations is poor. To tabulate:—

United States.

2XAF: Very fine in daylight; hardly audible at night.
2XAO: Always poor, especially at night.
8XP: Very fine in daytime.
8XK: Excellent on some nights.
8XAL: Excellent on some nights.
2XAL: Good only in daytime.

Australia.

2ME: Excellent with loud speaker strength 5:30–8:30 A. M. E. S. T., relayed 5SW recently; 5 SW coming 20,000 miles.

Java.

ANH: Good volume, 7–8 A. M.

Holland.

PCJJ and PCLL: Always received with a strong signal, almost any hour.

England.

5SW on 24 meters relaying 5XX. I have left this till the last for I want to write at some length about it. 5SW as received in this part of America is simply phenomenal. Using (0-V-2) every evening I can easily run the loud speaker 5–7 P. M. E. S. T. 5SW at 5 P. M. is as strong a signal as WEAF, 50 kw. (200 miles east), 492 m. 5SW 7:30–8:30 A. M. is received with good headphone strength. But from 2–7 P. M. (when England is in darkness and America in daylight) 5SW is as regular and dependable as many of our U. S. stations. One would think we were in the British Isles.

Big Ben is an old friend. We have been in the Savoy Hotel, Carlton Hotel, Ambassador Club, New Princess Restaurant, Hotel Cecil, and other places.

Some of the best programs are the organ recitals from Bishopsgate and Southwark Cathedral and the National Symphony concerts.

Now a word about the medium wavelengths. 2LO is the most consistent. Spain is next. I will tell about one night (January 21) which was a fine night for European reception:—(These stations were on according to *World Radio*). (After 5:30 P. M. E. S. T., dark here):—

303	meters	Nurnberg	Drowned out by WGR.
306	"	2BE	Fair dance music.
312	"	5NO	Carrier wave.
326	"	6BM	Drowned out by WPCH.
345	"	EAJ1	Very fine.
353	"	5WA	Fair.
361	"	2LO	Very fine — dance music.
375	"	EAJ7	Fair.
380	"	Stuttgart	Good.
385	"	2ZY	Good.
396	"	Hamburg	Drowned out by WPAP.
405	"	5SC	Drowned out by WLIT.
428	"	Frankfurt	Good.
470	"	Langenberg.	Under WRC.
492	"	5GB	Under WEAF.

It is unfortunate that WRC and WEAF are always on, making reception of these last two impossible.

RAYMOND M. BELL.
55 Wilson Street, Carlisle, Pennsylvania

The Remler A. F. Amplifying System

IN ENGLAND the argument as to whether the parts of a radio system should each be perfected or whether the whole system should have a "flat characteristic" has assumed much greater proportions than any such discussion in this country. This is due, no doubt, to the fact that few radio manufacturers prepare a complete tuner, or amplifier, or other assembly of radio equipment, but have been more interested in selling a part such as an audio transformer or a coil.

The curves in Fig. 2 represent the frequency characteristic of the new Remler audio-frequency amplifying system—about which we shall have an article in the near future. It is composed of two stages, as usual, each of which distorts somewhat. When combined, however, the defects of one stage are taken care of by the other so that a very good characteristic results. The advantage of such "matching" of one unit to another lies in the greater over-all amplification that can be secured. For example it is not possible to build at reasonable cost a 6.5 to 1 audio transformer that will not fall off in voltage step-up at low frequencies. When added to another stage which rises at the low end the result is as shown.

The average gain of a two-stage audio system using high grade parts is about 50 TU. This curve shows that the Remler amplifier has a gain of 57 TU or a difference of voltage step-up of from 300 to approximately 710.

—KEITH HENNEY

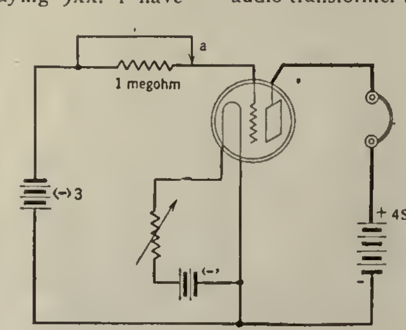


FIG. 3. A CIRCUIT FOR TESTING HARD AND SOFT TUBES

width of the exposure corresponds in loudness to the sound input to the system. The exposure is also made through a narrow slit.

In reproduction (Fig. 4) the film is run through the projector at the same speed. If the speed in the projector is higher than standard, the reproduced notes will be sharp; if lower, flat. A constant source of light shines through a narrow slit similar to that found in the recorder onto the sound track of the film. A photoelectric cell receives the light passing through the sound track. The light it receives through the film at each instant depends on the density of the record at that point, or its width, depending on which method of recording is used. In either case the output of the photo-electric cell should be proportional to the original intensity of the sound. The current output of the cell is only a fraction of a microampere, but two or three stages of audio amplification bring it up a level where it can be handled by amplifiers of the usual broadcast type, followed by an output stage the size of which depends on the amount of volume required. In one type the output stage, in large houses, utilizes four tubes in push-pull parallel, each having an oscillator rating of 50 watts; the total power delivered to the plates is about 200 watts, so it may be conjectured that 30–40 watts of undistorted audio energy are delivered to the loud speakers. The power stage is preceded by six stages of audio amplification. The usual gain controls, meter panels, etc., are on the panels.

The speakers are mounted above, behind, or

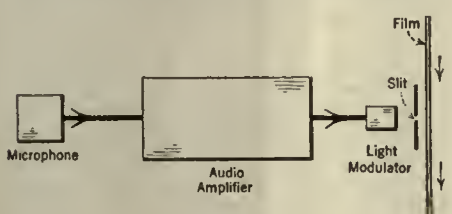


FIG 3.

on the sides of the motion picture screen. In some cases they are made to "fly" with the screen, i. e., the speakers are attached to the screen and may be pulled up with it into the scenery loft. Or the speakers may be pushed around on trucks backstage. The proper number, location, and orientation of speakers depends on the power of the outfit and the acoustic characteristics of the house.

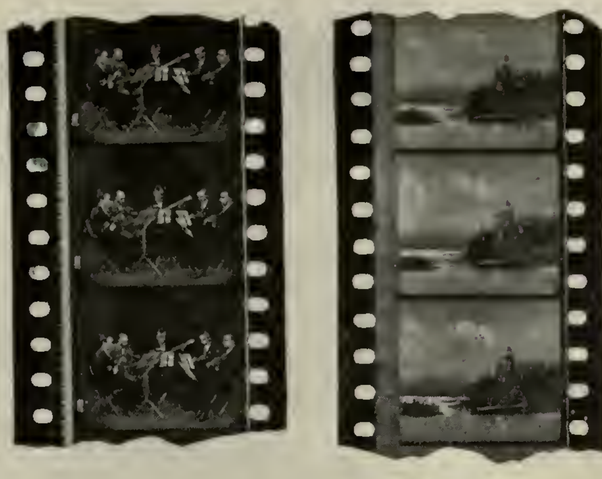


FIG. 2. TWO "TALKIE" FILM STRIPS

The two talking movie film strips, reproduced above in exact size, show how the sound record is photographed on the film. In the film at the left the sound is recorded as a zigzag line at the left of the film. In the strip at the right, the sound track at the left of the film is made up of bands of varying degrees of darkness extending the full width of the sound track

Lord Rayleigh on Sound

IN THE May, 1928, issue of the I. R. E. *Proceedings* there is a review of Lord Rayleigh's treatise on the "Theory of Sound." The book has recently been issued in a revised edition, two volumes, 494 pages, by Macmillan in London. The I. R. E. review is by Harvey Fletcher of the Bell Telephone Laboratories. My comments are a review of a review, but there is enough substance and inspiration in Rayleigh's classic work on sound to stand that attenuation.

Few broadcasters have the physical background to appreciate Rayleigh's book equation by equation, but one has only to page it to realize that one holds the record of a great piece of work by a great physicist. Dr. Fletcher points out that "The Theory of Sound" has been the standard text on the subject for the last 50 years. The first edition appeared in 1877, the year in which Alexander Graham Bell demonstrated his invention of the electric telephone before the British Association of Science. The work on which the book is based was largely finished, therefore, before the invention of the telephone. Yet telephone engineers refer to it frequently, and no one can write a book on acoustics or vibrating systems without leaning hard on Rayleigh.

In a second edition which appeared in 1894 a chapter on "Electrical Vibrations" appeared among other additions. This marked the transition of the treatment of audio vibrations from the mechanical to the electrical aspects. But almost all the electrical theorems, however generalized and intricate, are found in the differential equations of Rayleigh's investigation of mechanical vibrating systems. Rayleigh perhaps never saw anything like a wave filter or an artificial line, but his grasp of the general meaning of oscillation was such that his analyses required only a little adaptation to be useful in dealing with such devices.

This unity of the acoustic past and present is manifested in some of Fletcher's sentences, as when he writes, "It is strikingly difficult to transmit energy of vibration from air to steel, or vice versa, for the amount which crosses the junction is only 0.00001 of that which arrives at it. In other words, a transmission loss (sometimes called a reflection loss) at a junction between air and steel is about 50 TU." Rayleigh expressed in TU tells us why a tuning fork makes as little noise as it does, even though it vibrates vigorously; fundamentally it is because air and steel are such different substances. The same loss occurs when we try to transmit oscillating electrical energy from one circuit to another with widely different constants.

Another interesting point brought out by Fletcher is Rayleigh's evident regard for the work of Heaviside, to which he frequently refers in the 1894 edition. Six years before the invention of the loading coil, Rayleigh discussed attenuation and distortion along lines, saying, "The cable formula . . . is an example . . . where waves of high frequency are attenuated out of proportion to waves of low frequency. It appears from Heaviside's calculations that the distortion is lessened by even a moderate inductance." This also appeared to Professor Pupin. Rayleigh goes on: "The effectiveness of the line requires that neither the attentuation nor the distortion exceed certain limits, which, however, it is hard to lay down precisely. A considerable amount of distortion is consistent with the intelligibility of speech, much that is imperfectly rendered being supplied by the imagination of the hearer." For this the telephone companies can still thank God.

Rayleigh also pointed out, in Fletcher's words, "the definite limitations of a horn radiating sounds having wavelengths larger than the opening of the horn." And, while we are admiring Sabine as he deserves, let us not forget the following paragraph which Fletcher has quoted from Rayleigh:

> In connection with the acoustics of public buildings there are many points which still remain obscure. It is important to bear in mind that the loss of sound in a single reflection at a smooth wall is very small, whether the wall be plane or curved. In order to prevent reverberation it may often be necessary to introduce carpets or hangings to absorb the sound. In some cases the presence of an audience is found sufficient to produce the desired effect. In the absence of all deadening material the prolongation of sound may be very considerable, of which perhaps the most striking example is that afforded by the Baptistery at Pisa, where the notes of the common chord sung consecutively may be heard ringing on together for many seconds. According to Henry it is important to prevent the repeated reflection of sound backwards and forwards along the length of a hall intended for public speaking, which may be accomplished by suitably placed oblique surfaces. In this way the number of reflections in a given time is increased, and the undue prolongation of sound is checked.

Rayleigh also deduced from the equations for the transmission of sound through air of uneven temperature that in the usual auditorium, where the air is warmer at higher points, sound will be refracted upward and consequently a speaker will be heard better by listeners above than below him.

As the viscosity of the air is small, sound waves do not decline rapidly in amplitude. The loss is greatest for the higher frequencies. A sound having a wavelength of one centimeter loses two thirds of its initial amplitude in travelling through 88 meters, while a graver sound, with a wavelength of 10 centimeters, suffers the same attenuation in traversing 8800 meters. The attenuation is proportional to the square root of the frequency.

"It is frequently stated," says Fletcher, ending his review, which contains more substance than many an original paper, "that when a treatise on a scientific subject has become 10 or 15 years old, it is ready for the cellar or the garret, its obsolescence being due to the rapid advances which science is making. This book on 'The Theory of Sound' is certainly an exception. It is now more than 50 years old and it will continue to be used for a good many years."

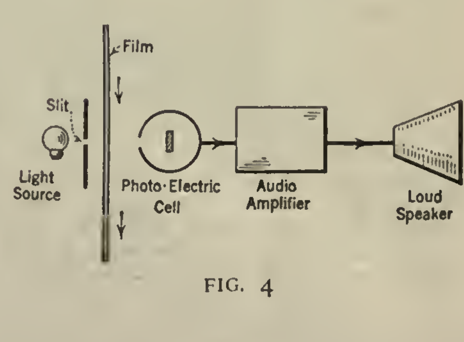


FIG. 4

A RECEIVER OF STRIKING APPEARANCE

The Sargent-Rayment receiver, with its aluminum cabinet and panel mounted upon a walnut base moulding, and black control knobs, presents an unusual and rather modern appearance which is perhaps more in keeping with the electrical age which it typifies than the more conventional wooden cabinets. The gang condenser control is in the center, and the volume control at the right; the other five knobs control the individual trimming condensers for balancing exactly the r. f. stages

The Sargent-Rayment Seven Receiver

By HOWARD BARCLAY

THE receiver described in this article is striking in that it departs successfully from many of the generally accepted tenets of home-built receiver design, and approaches the standards set by the higher priced factory-built sets costing up into the hundreds of dollars. It was developed by Messrs. Sargent and Rayment, the inventors of the Infradyne circuit which created considerable interest several years ago, and it embodies four individually shielded stages of t.r.f. amplification, a detector, and two audio stages of the Clough design. As it has several unusual features it is felt that a description of the salient engineering points of the design will be of interest to readers.

From the photographs and diagram it is seen that the receiver consists of an aluminum shielding assembly which serves the dual purpose of a cabinet for the entire receiver, and individual stage shielding for the different circuits of the set. This cabinet is made up of a pierced aluminum chassis, with the edges turned down, to which are fastened a number of smaller formed pans which serve as partitions, thus dividing the inside of the cabinet off into seven separate and distinct compartments. The assembly is completed by the front and back panels, which are bolted to the chassis and to all eight partitions, and finally by an aluminum cover, the edges of which are turned over to provide tight lap joints when the cover is placed on the receiver assembly. All of the metal work is of 7/64″ aluminum, which provides most satisfactory electrical shielding. The complete shielding assembly alone uses nearly fourteen pounds of aluminum; the size is 27⅞″ long, 12⅛″ wide, and 8⅛″ high. In the picture on this page the receiver assembly is shown mounted upon a walnut base moulding which trims up the appearance so that the set would not look out of place in the average living room. The aluminum assembly is finished in attractive satin silver.

Examination of the different illustrations and the circuit diagram in Fig. 1 shows that the amplification progresses from the antenna tuning circuit in the extreme left compartment of the aluminum shielding cabinet, through the four stages of tuned r.f. amplification to the detector in the sixth compartment. Four screen-grid tubes are used in the r.f. stages, and a 201A, or preferably a 112A, for detector. In the extreme right compartment is housed the 2-stage audio amplifier and output transformer with the volume control. The center compartment of the receiver is left vacant except for the drum control dial which turns all five of the tuning condensers. All stage compartments are 12″ deep, 6¾″ high, and 4⅛″ wide.

THE names Sargent and Rayment are probably familiar to many of our readers as the designers of the Infradyne, a receiver which has been described by our contemporary, Radio, on the Pacific Coast. The receiver described in this article is of the tuned radio-frequency type, employing four stages of r.f. amplification with type 222 tubes. The audio amplifier contains two transformer coupled stages.

Although all the tuning condensers are controlled from a single dial, the set cannot truly be considered a single control receiver, for to obtain the maximum possible results the designers have placed small midget condensers across each tuned circuit. This, we feel, is a good idea, for it means that each circuit can be definitely adjusted to exact resonance. To put together a receiver containing this number of r.f. stages and have each stage in exact resonance with all the others throughout the entire broadcast band would necessitate exceedingly accurate coil and condenser matching.

—The Editor.

PERFORMANCE

IN TESTS conducted upon different models of the Sargent-Rayment receiver during the period of its development, rather surprising results were obtained. On the West Coast, where the average receiver capable of giving adequate selectivity for other locations generally falls down quite badly, due to a number of peculiar local conditions, the Sargent-Rayment Seven has given positive 10-kc. selectivity—that is, it will separate distant stations ten kilocycles away from local broadcasters. As a specific instance, 10-kc. separation was obtained on either side of KGO in Oakland, Cal., and in the same location KRLD of Dallas was brought in between KFI and KFRC. This is very exceptional operation in this locality. Such selectivity seems to leave little to be desired, for the receiver will go down to the noise level and bring in on the loud speaker any station sufficiently louder than atmospheric noises to be distinguished from it. To many radio fans this statement does not mean very much because upon the less sensitive receiver it is seldom indeed that the noise level observed is ever so loud as to drown out signals. This is not true of the Sargent-Rayment, for a simple turn of the volume control knob will increase its sensitivity to a point where weak atmospheric noises come in with a roar under conditions which would

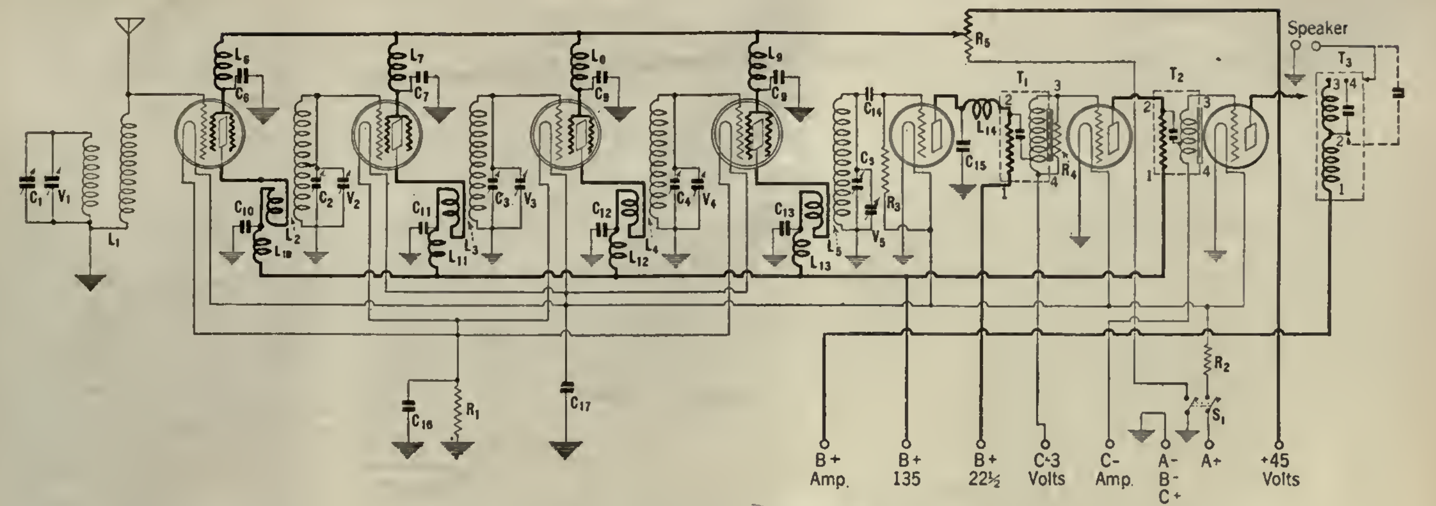


FIG. 1. THE SCHEMATIC WIRING DIAGRAM

If a 112A or 210 tube is used in the power stage, the plate lead of the power stage should be connected to terminal 3 of the output device, T_3; if a 171A or 250 tube is used, to terminal 2. Also note that if 180 volts or less is used with a 112A or 171A tube in the last stage, the speaker should be connected to terminal 4 of T_3 as indicated in solid lines. If more than 180 volts is used—as with a 210 or 250 tube—the speaker must be connected through a 600-volt 2.0-mfd. condenser to terminal 2, as indicated by the dotted lines

ordinarily be quiet for other receivers. Models of the receiver brought to Chicago and tested under the trying conditions produced by twenty or more local stations in simultaneous operation, have brought in as many as one hundred broadcast stations in a single evening's tuning. One receiver was tuned over the broadcast band, beginning at 550 kc. and going up the frequency scale. As rapidly as the dial could be turned and the verniers trimmed for maximum signal strength, new stations could be logged. When the evening was over, it was found that a station had been logged for every transmission channel, beginning at 550 kilocycles and going on up to over 1200 kilocycles before any gaps were found (channels upon which no station could be heard). This in itself is a remarkable record, and one which indicates the high degree of amplification that may be had in a carefully designed tuned radio-frequency receiver taking full advantage of the possibilities of screen-grid tubes and adequate shielding.

CIRCUIT DESIGN

ALL of the four r.f. stages consist of essentially similar tuning coils and tuning condensers associated with screen-grid amplifier tubes and the necessary bypass condensers and choke coils to insure absolute isolation of the various amplifier circuits. Each stage embodies an r.f. transformer with the secondary wound of 72 turns of No.25 plain enameled wire on a threaded bakelite tube 2½" in diameter, the winding occupying a space 2¼" inches long. The turns are spaced 32 turns per inch. The r.f. resistance characteristics of this coil are most excellent. To each of the interstage r.f. transformer secondaries is coupled a primary consisting of 25 turns of No. 28 d.c.c. wire, wound upon a 2¼" diameter bakelite tube, fitting inside the secondary at the filament end.

Upon close observation, the antenna coupling coil, L_1 in Fig. 2, will be found to differ slightly from the interstage coupling transformers in the succeeding r.f. stages. This coil is of the tuned rejector type, having a primary winding of 20 turns of No. 28 d.c.c. wire with the turns spaced ⅛" apart on a tube 2¼" in diameter. This winding is common to the antenna circuit and the grid circuit of the first r.f. tube. Surrounding this coil, and coupled closely to it, is a second coil which is similar to the secondary windings in the succeeding stages. This coil is tuned by the first or extreme left-hand tuning condenser and serves to reject effectively undesired signals, without having its tuning greatly affected by various sizes of antenna.

Examining a typical r.f. stage, it is seen to consist of the r.f. transformer; the 0.00035-mfd. tuning condenser with its associated 0.000025-mfd. midget vernier condenser; a tube socket for the screen-grid amplifier tube; two ½-mfd. bypass condensers, and two radio-frequency choke coils. Each amplifier circuit is complete in its own shielded compartment, and the only leads carrying r.f. current running from stage to stage are the plate leads. One of the ½-mfd.

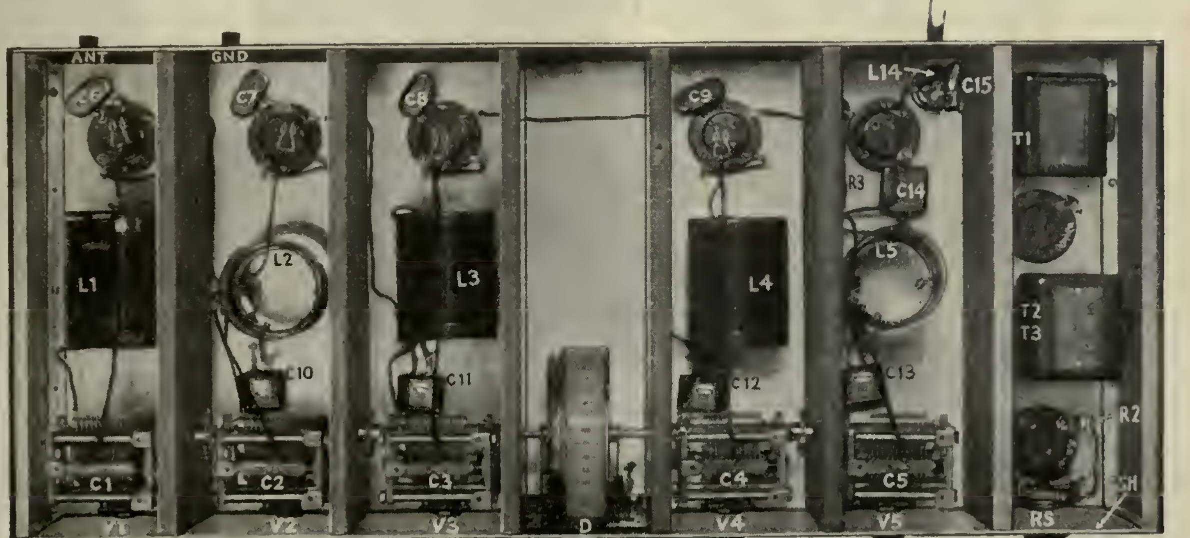


FIG. 2. WITH THE TOP REMOVED

From left to right are the four r.f. stages, the detector stage, and the two-stage audio amplifier housed in one compartment. In this compartment the second-stage audio transformer, T_2, is mounted on top of the output transformer, T_3. The five trimming condensers, V_1, V_2, V_3, V_4, and V_5, are mounted just under their respective tuning condensers. The mounting of the remainder of the parts above the sub-panel is clearly shown in this picture

condensers is connected from the screen-grid to the grounded shield, and one from the B plus side of the r.f. transformer primary to the grounded shield. Electrical isolation is further insured by the use of two r.f. choke coils, one connected in the screen-grid lead and one in the plate lead of each r.f. amplifier stage. These chokes are placed on the under side of the chassis. An additional r.f. choke is used in the detector plate circuit to prevent any r.f. currents from straying into the audio amplifier.

With all of these precautions, the receiver is remarkably stable; however, it is capable of being made to oscillate when desirable. A detailed analysis of the functioning of the screen-grid tubes as r.f. amplifiers indicates that even though the plate-to-grid capacity of the screen-grid tube has been reduced to an almost negligible value, this value is still high enough to allow oscillation if sufficiently good circuits are used with the tube. As very good circuits have here been employed to provide as high amplification and selectivity as is possible, the volume control has been combined with a stability control so that the r.f. amplifier stages may be operated at peak efficiency at every wavelength, regardless of oscillation tendency.

Measured amplification curves of the different stages show repeater voltage gains varying from 17 at 550 meters to 30 at 200 meters, these comparatively low values having been selected in order that the full merit of the tuned circuit might be taken advantage of to obtain the selectivity required by modern broadcasting conditions. The rising characteristic of the r.f. amplifier at short wavelengths is compensated by the tuned antenna input circuit, which has an opposite characteristic in that it shows greatest voltage step-up at 550 meters with a decreasing step-up at shorter wavelengths.

The five tuning condensers, C_1, C_2, C_3, C_4, and C_5, are all connected together, and are operated by a single drum control dial, this connection being effected by means of the floating removable shafts, and flexible couplings arranged to link the condensers. The receiver can be tuned over the entire broadcast band with the single tuning drum, no difficulty being experienced in ganging, due to the high accuracy of the double spaced condensers employed. It was felt desirable, however, to equip each stage with individual tuning verniers, V_1, V_2, V_3, V_4, and V_5, so that there would be absolutely no question in the mind of the operator that his receiver could always be tuned to absolute peak efficiency on any and all wavelengths in the broadcast band.

NOTES ON CONSTRUCTION

THE construction of the receiver is quite simple, for there is available for it the complete shielding assembly, fully pierced, and requiring only the insertion of some 88 $\frac{6}{32}$ screws with their nuts and lockwashers, to put it together. The use of this large number of screws to hold the shielding together is the result of an interesting fact discovered during the development of the set. At first an endeavor was made to use the simple and attractive corner-post type of assembly, attaching these posts to the chassis and slipping the partitions, ends, front and back panels into the slots of these corner posts. The result was a very attractive mechanical job, but of very poor electrical characteristics, for the electrical joints provided between the partitions and the chassis (and for that matter between the partitions and the corner posts) were of such a variable nature as to change the entire performance of the receiver. It was necessary merely to strike the shielding with the palm of one hand to change the electrical contact between the different portions of the shielding, thereby altering their shielding effects on the circuits. From these results it was found that it would be necessary to use lap-joints and thick aluminum and to insure positive contact at many points, which accounts for the use of nine fastening screws to each partition.

The parts, and accessories, used in the Sargent-Rayment Seven are listed at the end of this article, and being of standard manufacture, may all be procured upon the open market, including the especially prepared aluminum cabinet assembly. The coils may be wound at home from the data given in the text. The assembly of the receiver is quite simple, involving only the mounting of the parts upon the pierced chassis with machine screws, wiring them up, and finally, the attachment of partitions and front and back panels with the 88 machine screws previously mentioned. The wiring of the set is surprisingly simple for a receiver of this type, as may be seen from a study of the two pictures in Fig. 2 and Fig 3. The schematic wiring diagram in Fig. 1 also shows the simplicity of the wiring.

LIST OF PARTS

In the list below the substitution of equivalent parts may be made at the builder's choice.

- C_1 to C_5—5 S-M variable condensers, 0.00035 mfd., type 320-R
- C_6 to C_{13}—8 Polymet Bypass condensers, 0.25 mfd.
- C_{14}—1 Polymet Grid condenser, 0.00015 mfd.
- C_{15}—1 Polymet Bypass condenser, 0.002 mfd.
- C_{16}, C_{17}—2 Potter Bypass condensers, 1.0 mfd.
- D—1 National Velvet vernier dial, type F, with illuminator
- L_1—1 S-M antenna coil, type 141
- L_2, L_3, L_4, L_5—S-M r.f. transformers, type 142
- L_6 to L_{14}—9 S-M r.f. chokes, type 275
- R_1—1 Carter resistor, 3 ohms, type H-3
- R_2—1 Carter resistor, 1.0 ohm, type H-1
- R_3—1 Grid leak, 2 megohms
- R_4—1 Durham resistor, 150,000 ohms, with leads
- R_5—1 Yaxley Junior potentiometer, 3000 ohms, type 53000-P
- S_1—1 Yaxley Junior switch, double circuit (d.p.s.t.), type 740
- SH—1 S-M aluminum shielding cabinet with control legends, type 705
- T_1—1 S-M first-stage audio transformer, type 255
- T_2—1 S-M second-stage audio transformer, type 256
- T_3—1 S-M output transformer, type 251
- V_1 to V_5—5 S-M midget condensers, 0.000025 mfd., type 340
- 1 S-M walnut finish base moulding, type 706
- 1 S-M 10-lead battery cable, type 708
- 2 cartons S-M hook-up wire, type 818
- 7 S-M tube sockets, type 511
- 2 Yaxley insulated tip jacks, type 420
- 1 set hardware (obtainable from manufacturer)

The accessories necessary to make the set operative are as follows:

- 4 CX-322 r.f. tubes
- 1 CX-301A or, preferably, CX-112A detector tube
- 1 CX-112A first a.f. tube
- 1 CX-371A power tube
- 1 6-volt storage A battery or A-power unit
- 4 45-volt heavy-duty B batteries or a B-power unit (180 volts), such as the S-M 670-B Reservoir Power unit
- 1 $40\frac{1}{2}$-volt C battery
- 1 $4\frac{1}{2}$-volt C battery

If it is desired to use a CX-350 type power tube in place of the 371 in the last stage, a high-power A-B-C supply, such as the S-M 675 ABC Hivolt Power supply, should be used. In this case only the $4\frac{1}{2}$-volt C battery is necessary, and a 2-mfd., 600-volt condenser must be placed between the speaker and terminal 2 of the output transformer, T_3, (see Fig. 1.)

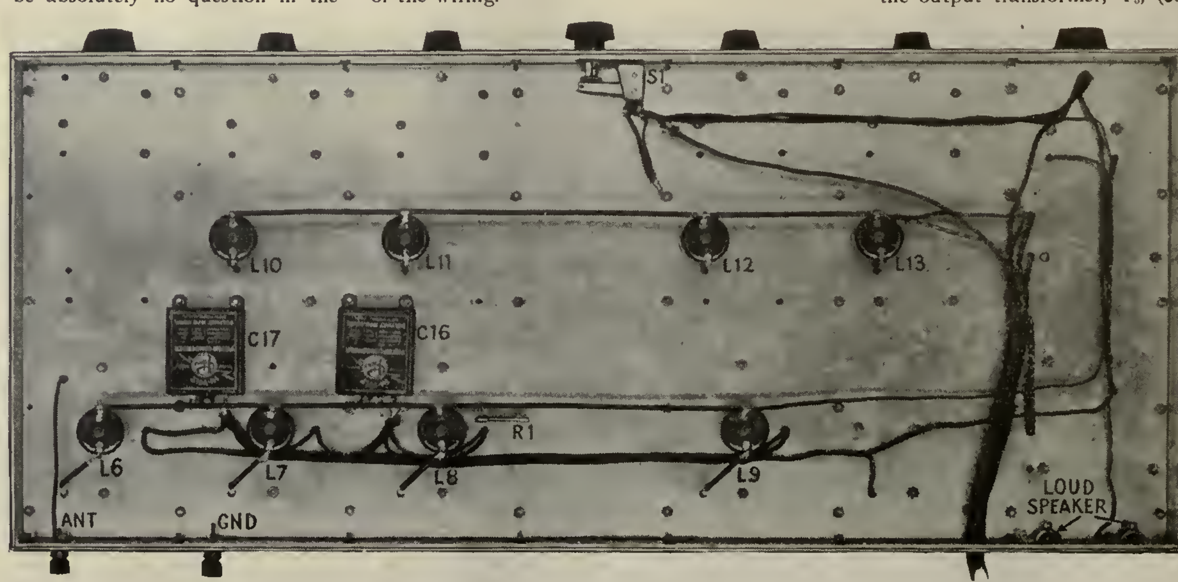


FIG. 3. THE UNDER SIDE

This view gives an idea of the simplicity of the wiring of the receiver, resulting from the use of the metal chassis as the A minus circuit return. The mounting of the condensers and chokes on the under side of the chassis is also clearly shown

No. 7 RADIO BROADCAST'S HOME STUDY SHEETS October, 1928

Alternating Current

Part I

AN ALTERNATING current is one in which the magnitude and direction of flow of the current are continually changing. A direct current flows steadily in a given direction and at a more or less constant magnitude. The laws governing direct current phenomena and apparatus and the associated circuits are fairly simple; Ohm's Law will enable the experimenter to solve nearly all d.c. problems he runs into. The laws of a.c. circuits, on the other hand, are more complex—but for this very reason provide more enjoyment for the experimenter and those who like to solve problems.

Home Study Sheet No. 3 shows how Ohm's Law is to be applied to some radio problems; this Sheet gives the fundamental facts about alternating currents.

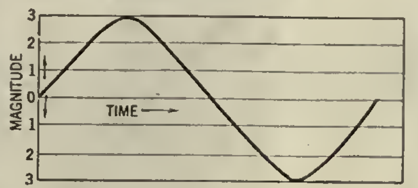


FIG. 1

DEFINITIONS

At regular intervals the direction of flow of an alternating current reverses, and therefore its variations in magnitude are as follows: the voltage starts at zero, rises to a maximum in one direction, decreases to zero, changes its direction, increases to a new maximum and then falls to zero, after which the CYCLE is repeated. Figure 1 is a representation of a single cycle of a.c. voltage. Such a picture is called a SINE WAVE. The number of times a second this cycle is repeated is called the FREQUENCY; the time required for one cycle is the PERIOD.

House lighting currents are usually of 60 cycles although in some localities 25-cycle and 133-cycle circuits exist. So slowly do the alternations take place on a 25-cycle circuit that lights burning from them seem to flicker, although people who have never seen lights operated from circuits of higher frequency seem not to notice the unsteadiness of their own illumination. Audio-frequency currents have frequencies ranging from as low as the ear can hear, about 32 cycles per second, to as high as we can hear, about 15,000 cycles per second. Radio circuits have frequencies ranging from about 10,000 cycles to as high as 30,000,000 cycles. Long-wave transoceanic communication takes place on the lower radio frequencies, broadcast transmissions on frequencies between 550,000 and 1,500,000 cycles, short-wave communication from 1,500,000 to 30,000,000 cycles. A kilocycle is one thousand cycles.

PLOTTING AN A. C. CURRENT

To show graphically what happens when an alternating current flows, let us look at Fig. 2 which consists of a circle in which is a rotating arm attached to the center and touching the circumference—a rotating radius. Suppose the circle moves to the right—carrying with it the rotating arm—at a constant speed such that it moves the distance of its diameter in the time it takes the rotating arm to make one complete rotation in a counter-clockwise direction. Suppose a piece of chalk is attached to the end of the arm touching the circle. What sort of figure would it trace out as the two motions referred to take place? It would be a wavy form exactly like the alternating current curve in Fig. 1. The arm represents (mechanically) the rotating armature of an a.c. generator; the movement of the circle to the right represents the passage of time. The curve is a graphic representation of the changing values of an alternating current.

PHASE

Since a complete circle has 360 degrees, we may speak of the position of the arm in terms of the number of degrees it has rotated within the circle. When it is perpendicular to its starting position it has traversed one quarter of 360 degrees or 90 degrees; when it is parallel but pointing in the opposite direction, it has gone through 180 degrees, or one ALTERNATION, and so on. These various positions of the rotating arm are called its PHASES. Thus we speak of the 90-degree phase, and so on.

Since the magnitude of the voltage in an a.c. circuit is continually changing, it becomes expedient to have a means of knowing what the voltage is at any particular instant. At 0 degrees it is zero, at 90 degrees it is maximum, at 180 degrees it is zero again, at 270 degrees it is maximum, but in the opposite direction, and at 360 degrees the cycle is completed, and the voltage is again zero.

A.C.—INSTANTANEOUS VALUE

The INSTANTANEOUS value of an a.c. voltage or current is always referred to with regard to the maximum value. That is, if we multiply the maximum value by some factor which connects it and the phase, we shall have the instantaneous value.

A measure of the instantaneous value is the vertical height of the end of the rotating arm above the horizontal axis. The vertical height is measured by the length of the line dropped perpendicularly from the end of the arm to the horizontal axis; it is known as the vertical component. Now let us remove the vertical arm and its accessory lines from its circle and make what is known as a vector diagram at the 45-degree phase. In Fig. 3 let us label the arm, E (maximum voltage), the vertical component e (instantaneous voltage), and the angle which represents the phase, ϕ. Now if we divide the vertical component by the length of the arm, that is, e/E, we shall have a ratio which is defined mathematically as the SINE of the angle, usually written sin ϕ. This is the factor which connects the length of the arm and the vertical component.

Thus $\sin \phi = e/E$ or $e = E \sin \phi$

The numerical values of the sines of a number of angles are given in Table 1, and with their use we have a means of calculating the instantaneous values of a voltage provided we know the maximum value and the phase angle in degrees. At 90 degrees the vertical component is equal to the arm E and so the instantaneous value of the voltage at this phase is the maximum value. Can you prove this mathematically, using the data in Table 1?

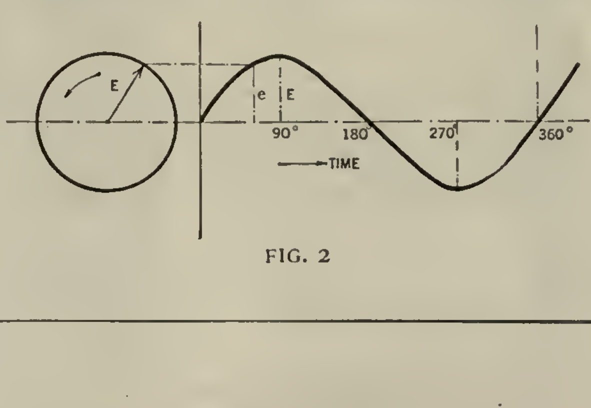


FIG. 2

EFFECTIVE OR R.M.S. VALUE

Since an alternating current is reversing at a rapid rate, the needle and mechanism of an ordinary d.c. meter would indicate only an average value which would be zero. Some other means must therefore be provided for comparing an a.c. current with a d.c. current.

We say, therefore, that an a.c. current is equal to a given d.c. current when they produce the same heating effect, and this value of the a.c. current is called its EFFECTIVE value. It is equal to the maximum value divided by the square root of 2, or

$$I_{eff.} = \frac{I_{max.}}{\sqrt{2}} = I \times .707$$

and

$$E_{eff.} = \frac{E_{max.}}{\sqrt{2}} = E \times .707$$

Since the heating effect of a current is proportional to the square of the current, we may obtain the effective or heating value over a complete cycle of alternating current by taking the average of the squares of several instantaneous values of current and extracting the square root. This value of current is then the square root of the average or mean squares of a number of values of current. This is abbreviated to "root mean square" or r.m.s., which is another term for effective value. In this expression "mean" and "average" have the same meaning.

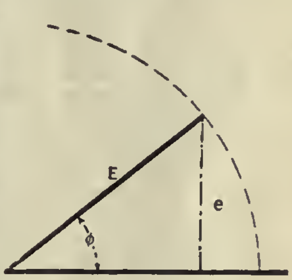


FIG. 3

The maximum or "peak" value of an a.c. voltage is used in determining the C bias necessary for an amplifier; the r.m.s. value is used in all power problems. It may be obtained by dividing the maximum value by 1.4 or by multiplying the maximum value by 0.707. Meters for use on a.c. circuits indicate the effective or r.m.s. values. The form of the wave in well regulated a.c. power circuits is nearly a true sine wave, that is, one in which the relation between the length of the rotating arm (the maximum value E or I) and the vertical component (the instantaneous value e or i) is the sine of the angle between the arm and the horizontal axis. If the a.c. current is not a true sine wave these relations do not hold.

PROBLEMS

1. Express in kilocycles the values of frequency given in paragraph four of this Study Sheet.
2. Assume that the maximum value of an alternating current is 10 amperes. On cross section paper plot its instantaneous values through one complete cycle by using the data in Table 1.
3. The effective value of an a.c. voltage is 110 volts. What is the maximum value?
4. What is the effective value of current in a circuit in which the maximum value of current is 10 amperes?
5. The maximum value of a certain current is 10 amperes. What is the phase when the instantaneous value is 5 amperes?
6. In a certain circuit the effective value of the voltage is 15 volts. What is the instantaneous value of the voltage at the 45 degree phase?
7. Check the relation between maximum and r.m.s. values by getting the square root of the average squares of several currents as plotted in Problem 2.
8. If power in watts is equal to $(I_{r.m.s.})^2 \times R$, what is the power used up in heating a resistance of 10 ohms when the peak voltage is 10?
9. Express by means of a vector diagram and in a formula the voltage in a circuit at phase 45 when the maximum value is 20.
10. Tell all you can about what the equation, $e = 10 \sin 30°$, means.

TABLE I

Angle in Degrees	Sine
0	0.0
30	0.5
45	0.7
90	1.0
120	0.87
180	0.0
270	—1.0
360	0.0

Alternating Current

Part II

IF THE experimenter wishes to know the difference between a.c. and d.c. circuits, let him try to measure the current flowing through a 30-henry choke when placed across the 90-volt tap of his plate supply unit, and then when placed across the 110-volt a.c. line. Evidently the choke has a much different effect on an a.c. line than it does on a d.c. line. What is this difference?

Let him, too, try to measure the current through a 1-mfd. bypass condenser when placed across this 90-volt tap, and across the 60-cycle line. Here again we see the difference between d.c. and a.c.

The choke—another name for an inductance—passes much less current on 60 cycles than it does on d.c.; the condenser passes none at all on d.c. and an appreciable amount on 60 cycles.

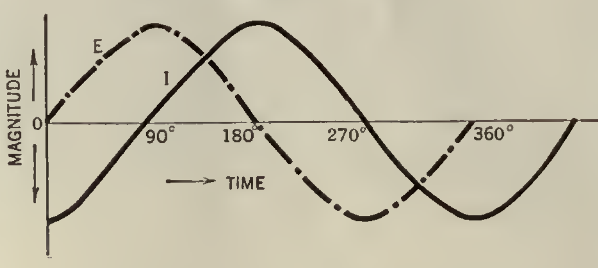


FIG. 1

INDUCTIVE REACTANCE

The opposition to the flow of a.c. currents offered by a coil of wire is proportional to its INDUCTANCE, the property of a coil which tends to prevent any change in the flow of current. If one could measure the rate at which the current flows into a choke coil and the rate at which it flows into the same length of wire stretched out straight, he would see that the final value of the current was attained much later when flowing into the coil. The same fact would be observed were the current flowing out of the coil or straight wire. The spark which takes place when the connection from a battery to an iron core choke is broken is evidence that the current tends to keep on flowing even after the connection is broken.

How does an inductance tend to prevent changes in current?

Such a tendency is the result of several fundamental electrical phenomena. In the first place, when current begins to flow into a coil, lines of force from each turn of wire extend themselves out from the coil to form what is called the magnetic field of the coil. In the second place, whenever a line of force cuts across a conductor, or vice versa, a voltage is induced in that conductor. Thus, when the many lines of force thread their way through the coil of wire, each turn of wire is cut by the lines of force from the other turns, so that a voltage is built up across the terminals of the coil. Now the third fundamental fact is that the voltage, which is called the "induced" voltage, is in such a direction that it tends to prevent any increase or decrease of current in the coil.

We have the following phenomena then to explain the effect of inductance on changes of current: current flows into the coil causing lines of force to cut the individual turns of the coil; this in turn induces a voltage in the coil which has such a polarity that the increase in original current flowing into the coil is retarded.

When the connection is broken the opposite effect takes place; that is, the induced voltage tends to prevent the decrease of current with the result that its existence is prolonged. This voltage, then, must be in the same direction as the voltage tending to force current into the coil, so that across the ends of the coil, or the break in the circuit, a large voltage is built up. This voltage consists of the original impressed voltage from a battery, for example, plus the induced voltage. This explains the spark which takes place and the rather severe shock which may be felt from even small impressed voltages and a small coil.

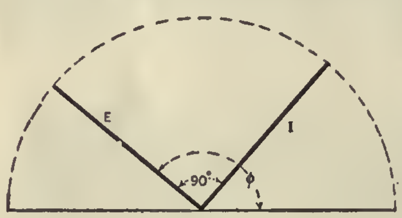


FIG. 2

It is important to note that it is only when the current in the coil is changing—increasing or decreasing—that the lines of force in the magnetic field change. And it is only the *changes* in the lines of force that give rise to induced voltages; hence the retarding effect of an inductance occurs only when the current flowing changes.

Since an alternating current is continually changing, increasing in value, reversing its direction of flow, decreasing in value, etc., the opposition which inductance offers to its flow is considerable.

The opposition which an inductance offers to the flow of alternating currents is measured in ohms just as resistance is, and its technical term is REACTANCE. The reactance of a coil depends upon the frequency of the current and the inductance of the coil, and is numerically equal to 6.28 times the inductance in henries times the frequency in cycles. The abbreviation and formula for inductive reactance are

$$X_L = 6.28 \times f \times L$$

Thus, doubling the frequency doubles the reactance in ohms, so does doubling the inductance at the same frequency.

Since the current into an inductance does not rise to its maximum value instantly, there is a lag between the times of maximum voltage and maximum current. The maximum current is not reached in a pure inductance (no resistance) until the voltage has gone through 90° of its cycle. The current in an inductive circuit, therefore, is said to LAG behind the voltage. This is illustrated in Fig. 1, in which the maximum values of the current and the voltage are 90° apart. It is also shown in the vector diagram Fig. 2 which represents two arms rotating at the same speed but 90° or one fourth of a cycle apart.

Since the maximum values of the current and voltage are 90° apart, we must take this fact into recognition when we desire to know the instantaneous values of the current. If the voltage is at the 150° phase, the current is 90° behind it or at its own 60° phase. This difference of 90° is called the ANGLE OF LAG, or the PHASE ANGLE between the voltage and the current. The instantaneous value of the current is expressed by

$$i = I \sin (\phi - 90°)$$

EXAMPLE. What is the instantaneous current at the 150° phase in an inductive circuit in which the maximum current is 10 amperes?

$$\begin{aligned} i &= 10 \sin (150° - 90°) \\ &= 10 \sin 60° \\ &= 10 \times .87 = 8.7 \text{ amperes.} \end{aligned}$$

Figure 3 is the vector diagram illustrating this problem. It is drawn to scale so that the various lengths of line represent the various values of current and voltage.

CURRENT IN INDUCTIVE CIRCUITS

Just as the current in a resistance circuit is expressed by Ohm's law, whether it is d.c. or a.c., so is the current in an inductive a.c. circuit expressed by a similar formula.

$$I = \frac{E}{X_L} = \frac{E}{6.28 \times f \times L}$$

and if the voltage is effective, or maximum, or instantaneous, the current will be effective, maximum, or instantaneous.

PROBLEMS

1. Plot the reactance of a coil of 0.1 henry as the frequency is increased from 100 to 10,000 cycles, and then from 10 to 1000 kilocycles. What would the reactance be if the inductance were 1 millihenry? One henry?

2. A coil has the following dimensions: length of winding, 2 inches; diameter, 3 inches; number of turns, 65. What is its reactance to a current of 750 kilocycles? What current would flow through it if the voltage (effective) were 10? (See Home Study Sheet No. 2, July RADIO BROADCAST.)

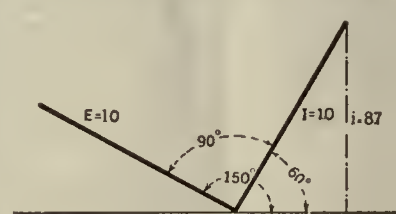


FIG. 3

3. Make a vector diagram for the following condition and solve by means of the formula above. The instantaneous voltage at the 135° phase is 5 volts; what is the instantaneous current if the effective current is 5 amperes? The circuit is inductive.

4. How much inductance must be placed in a 110-volt (effective) circuit at 60 cycles to limit the current to 1 ampere? At 6000 cycles?

5. The maximum value of the voltage in an inductive circuit is 140, the maximum current is 10 amperes. At what phase is the instantaneous current equal to 7 amperes? What is the instantaneous value of the voltage? What inductance must be added to reduce the maximum current to 7 amperes if it is a 133-cycle circuit? What will be the effective current then?

6. Can you explain why a 25-cycle transformer is larger, heavier, and more expensive than one built for 60 cycles? What would be the result of placing a 60-cycle transformer on a 500-cycle circuit? What would happen if a 500-cycle transformer were placed on a 60-cycle circuit?

7. Suppose you couple a loud speaker to an output tube by means of a choke and a condenser. The output a.c. voltage at 1000 cycles is 50; this appears across the choke which has an inductance of 30 henrys. What a.c. current flows through the choke? If the condenser offers no impedance to the flow of current at this freqüency, and if the loud speaker which is, then, shunted across the choke, has an impedance of 4000 ohms, how much a.c. current flows through it? Suppose the power into the loud speaker is equal to the current squared multiplied by the impedance of the speaker. What power is going into the speaker? Suppose 2 per cent. of this electrical power is turned into sound energy by the speaker. How many watts of sound output power comes from the speaker? How many micro-watts?

8. Draw the diagram of a two-stage audio amplifier using 3-1 transformers working out of a detector tube which has an impedance of 20,000 ohms, the power or second stage working out of a tube with an impedance of 12,000 ohms and a mu of 8. These plate impedances are in series with the impedance of the primary of the following audio transformer. Suppose across the first audio primary is 0.5 volt at 100 cycles. The transformer primaries have effective inductances of 100 henrys. Figure the a.c. current in the plate circuit of the detector and the first audio tubes. (Combine the tube and transformer impedance by adding them.)

The 222 Tube as an R. F. Amplifier

Part II

By GLENN H. BROWNING

IN THIS, the second article from Mr. Browning's notebook on the 222 tube, the author discusses two common methods of coupling a screen-grid tube to a detector or to a following amplifier. The equations by which Mr. Browning arrived at his conclusions should be interesting to the mathematically inclined; the results of those equations and the laboratory data will be interesting to anyone who likes to keep up to date in radio.

—THE EDITOR.

IN THE article on page 252 of September RADIO BROADCAST the characteristics of d.c. and a.c. types of screen-grid tubes were discussed and their performance in untuned amplifiers was also considered. It is the object of this article to treat of two types of tuned radio-frequency amplifiers, one the common radio-frequency transformer where a primary and secondary winding is used, and the other the auto-transformer usually termed tuned impedance.

The function of a tuned radio-frequency amplifier is not only to amplify incoming signals but also to give the desired amount of selectivity. There is also the question of the tendency of the preceding circuits to oscillate, which is very important with tubes which have a great deal of capacity between grid and plate. This effect, however, is minimized with the screen-grid tube, and consequently will not be dealt with at length here.

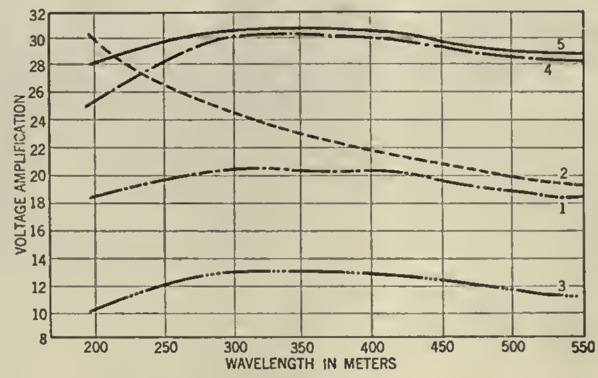
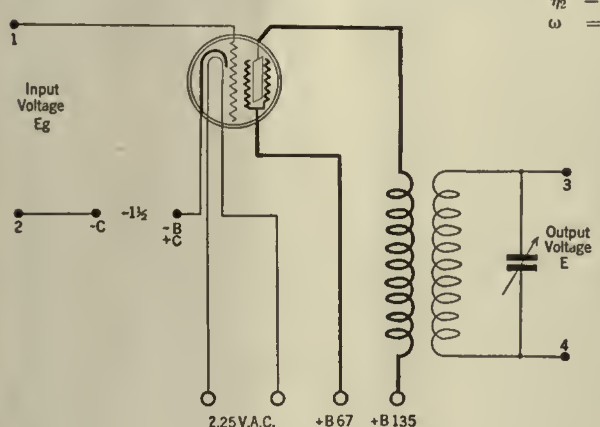
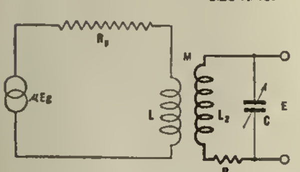


FIG. 3

Theoretical and actual voltage amplification curves over the broadcast band for the types of r. f. coupling discussed in this article





ABOVE—FIG. 1. TO THE LEFT—FIG. 2.

The circuit diagram and its schematic equivalent circuit for a stage of r. f. using a t. r. f. transformer

To determine the design of an r.f. transformer for the screen-grid tube the mathematics for a one-stage amplifier such as shown in Fig. 1 should be examined and the voltage amplification, i. e., output voltage, E, divided by input, E_g, calculated. As far as alternating current is concerned Fig. 1 reduces to Fig. 2, where a voltage of μE_g is applied in series with the plate resistance, R_p, and the primary of the transformer. Analyzing this circuit and making certain simplifications the voltage amplification is

$$\frac{E}{E_g} = \frac{\mu \tau \sqrt{L_2/L_1}}{\tau^2 + \eta_1 \eta_2} \qquad (1)$$

Where μ = amplification factor of the tube
τ = coefficient of coupling between primary and secondary
L_2 = Secondary inductance in henrys
L_1 = Primary inductances in henrys
$\eta_1 = R_p/L_1\omega$
$\eta_2 = R_2/L_2\,\omega$
$\omega = 2\pi$ frequency

It will be readily seen by equation 1 that there is a relation between η_1, η_2 and τ that will make the amplification a maximum. This relation is

$$\tau^2 = \eta_1, \eta_2 \qquad (2)$$

for maximum voltage amplification.

The amplification obtained by the transformer and tube when this relation is satisfied is

$$\frac{E}{E_g} = \frac{\mu\sqrt{L_2/L_1}}{2\sqrt{\eta_1 \eta_2}} \qquad (3)$$

From this analysis it may be seen that L_2 should be as large as possible consistent with tuning down to the lowest wavelength desired. L_1 should be as small as possible consistent with satisfying the relation $\tau^2 = \eta_1 \eta_2$.

It should be noted that when L_1 is small that η_1 is large and consequently the coupling must be increased. Thus it is advantageous to make the coupling large consistent with keeping the capacity between the primary and the secondary windings small, as this capacity between the two circuits has the effect of introducing a voltage in the secondary circuit somewhat out of phase with the voltage induced by the magnetic coupling.

With the ordinary 199, 201A, 226, and 227 type tubes, the plate resistance is sufficiently low so that all the above relations may be satisfied, and maximum gain may be obtained. (See *Proceedings of Institute of Radio Engineers*, December, 1926.)

However, with the screen-grid tube the plate resistance is between 400,000 and 700,000 ohms so that η_1 is very large and the relation $\tau^2 = \eta_1 \eta_2$ can never be satisfied. Of course the primary inductance of the r.f.t. may be increased up to the point where the distributed capacity of the winding itself tunes the primary to some frequency in the wavelength band. η_2 is made as small as possible but can never be reduced below a value of about 0.003 except with regeneration. Therefore, it is essential in the design of a transformer for the screen-grid tube to make the coupling very large. This problem was attacked by the writer some months ago and by careful design the coefficient of coupling was increased from its usual value of about 0.5 to 0.91. This factor depends upon the geometrical relation between primary and secondary in such a way that the shorter the secondary winding with the primary in a given position the larger τ becomes. The coils which showed a τ of .91 were wound on a 2″ form and had a winding length of $\frac{9}{16}$″. The primary was slot wound and placed $\frac{1}{4}$″ from the low potential end.

With these coils in the one-stage amplifier the circuit of which is shown in Fig. 1, and using a CeCo a.c. 22 tube, an amplification of about 20

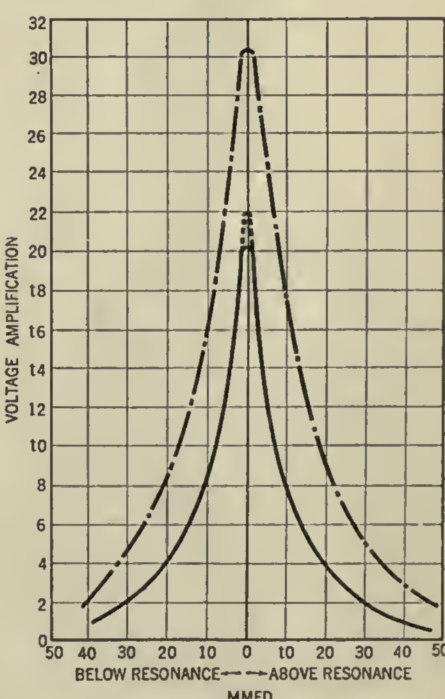


FIG. 4

The solid curve is the actual resonance curve of the transformer shown in Fig. 1 and 2 at 400 meters. The dotted peak is the portion of the calculated curve which does not coincide with the actual curve. The dot-dash curve is the resonance curve of the tuned impedance shown in Figs. 5 and 6

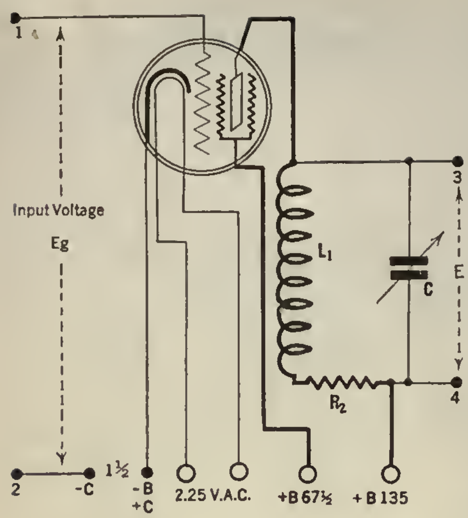


FIG. 5
The circuit of a stage of tuned impedance r. f. amplification using a screen-grid tube

per stage could be obtained. The method of measuring this gain was to put in a signal from an r.f. oscillator of 0.1 volt, as measured on a Rawson Thermal Multimeter, and to measure the voltage developed across points 3 and 4 by means of a vacuum tube voltmeter. The results are shown in Fig. 3. In curve 1 voltage amplification is plotted against wavelength. The theoretical amplification as calculated from equation 1 is shown by curve 2. The discrepancy between measured values and calculated ones is probably due to the capacity between primary and secondary windings of the r.f.t., as the effect of any capacity would be more pronounced on the short than on the long wavelengths.

As a matter of comparison the amplification of a 201A tube used in conjunction with a well-designed transformer is shown by curve 3. Not only does the screen-grid tube with the transformer described above give more amplification per stage, but furthermore a number of stages may be used without neutralization, whereas with the 201A, careful neutralization is necessary.

Before considering the amplification given by a tuned impedance, let us consider the selectivity obtained with the transformer and the Ceco a.c. 22 tube. The selectivity depends primarily upon the resistance, R_2, inherent in the coil and condenser in the secondary circuit. However, this resistance is increased due to the effect of the primary. Instead of considering the resistance itself let us consider $\frac{R}{L\omega}$ which is nearly constant over the wave band and gives directly the sharpness of tuning of the circuit. The smaller this factor the sharper the circuit tunes.

For a given amount of amplification the selectivity of the radio-frequency transformer as a whole depends upon the coefficient of coupling, so that when it is increased to obtain amplification the selectivity of the transformer is also increased.

The solid curve in Fig. 4 shows the resonance curve of the transformer at 400 meters where amplification is plotted against capacity of the tuning condenser above and below resonance. The calculated curve falls for the most part on the measured curve except that the theoretical curve is slightly higher as shown by the dotted line.

Let us now consider the amplification and selectivity of the screen-grid tube using tuned impedance as shown in Fig. 5, with the equivalent circuit Fig. 6. In this case the gain is given by

$$\frac{E}{E_g} = \frac{R_2}{\eta_2^2 R_p + R_2} \qquad (4)$$

so that the smaller the resistance in the secondary circuit and the smaller η_2 the larger the amplification. Fig. 3, curve 4, shows the amplification measured while using a 2″ coil. The calculated curve, 5, in this case is quite close to the measured values, 4. However, the apparent selectivity of the tuned impedance amplifier as shown by the dot-dash curve in Fig. 4, is not as good as in the case of the transformer. There seems also to be another disadvantage in using tuned impedance which is due to the tendency of the circuits to oscillate when using only two stages. The writer has been able to build with careful shielding a two-stage r.f. amplifier using the transformers described without the slightest tendency to oscillate. Regeneration on the detector was possible with the result that tremendous signal strength and fine selectivity were obtained, while with tuned impedance considerably more care was necessary to get two stages to be stable, and even then it seemed as if the signal strength were no greater than with the transformers plus regeneration, while the selectivity of the two systems was not to be compared.

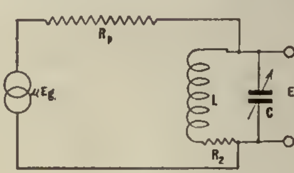


FIG. 6
The equivalent schematic circuit of Fig. 5

Book Review

By CARL DREHER

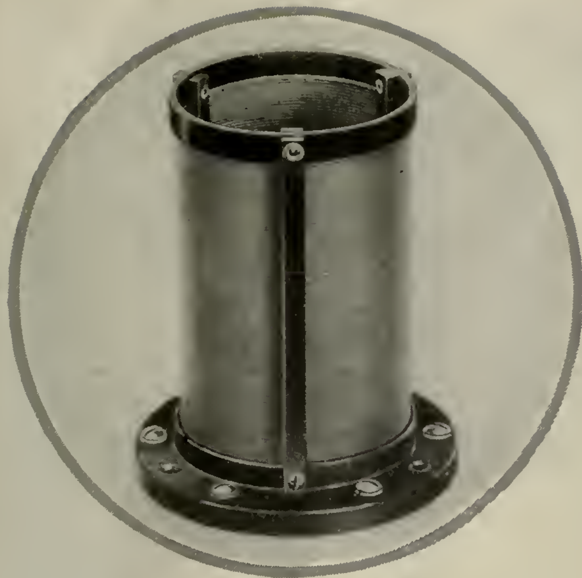
WIRELESS DIRECTION FINDING AND DIRECTIONAL RECEPTION. By R. Keen. Iliffe & Sons, Ltd., London. 490 pages. 1927. 21s.

THE statement that a given work is indispensable to those interested in the subject is a much misused cliché of technical book-reviewing, but in the case of Keen's "Wireless Direction Finding and Directional Reception" it is merely the literal truth. This book was first published in 1922 under the title of "Direction and Position Finding by Wireless." In the second edition the title was changed to include directional aërial systems, which had in the meantime assumed importance. Keen's work is an important contribution to the specialized literature or radio. It is a serious technical job and not intended for those to whom radio is a plaything. The mathematics is fairly simple, but the vectorial and diagrammatic treatment is very thorough and obviously designed for the attention of engineers and engineering students.

After an introduction, which includes an impartial historical treatment of the subject, directional transmission and reception are discussed. The wave antenna of Beverage, Rice, and Kellogg is described at the end of Chapter 2. The third chapter is devoted to "Frame Aërial Reception." This is discussed in detail, such topics as "Elimination of Vertical" (the antenna effect of a loop, which plays a part in reception) being treated. The theory of practical systems of this type is comprehensively stated and the chapter closes with a discussion of "Fallacies in Heart-Shape Circuits," this being a study of difficulties found in cardioid-reception circuits using a combination of loop and antenna pick-up. The following chapter describes the characteristics of rotating loop installations of the following types: Radio Communication Company, Ltd., Societé Française Radio-Electrique, Gesellschaft für Drahtlose Telegraphie (Telefunken), Siemens Brothers and Company, Ltd., U. S. Bureau of Standards, Washington, Marconi's Wireless Telegraph Co., Ltd., Radio Corporation of America, and the Federal Telegraph Company. The descriptions are quite extensive and well illustrated with diagrams and photographs. Chapter 5 is devoted to an analysis of the Bellini-Tosi system, which uses large fixed loops for directive transmission and reception. Another chapter goes into the theory and practice of map drawing. The radio engineer will have his hands full with such terms as "The Gnomonic Graticule," "The Retro-Azimuthal Chart," "The Orthomorphic Cylindrical Projection"; in this chapter and the one following, on "Position Finding and Wireless Navigation," he will have it brought home to him that radio direction finding is as much a branch of geography and navigation as of wireless communication.

Chapter 9, on "Night Effect and Other Freak Phenomena" is of general interest to students of the vagaries of radio transmission. In the following two chapters the discussion returns to types and characteristics of apparatus on shore and afloat. Theory, testing, calibration, and operation are considered in turn. Chapter 12 tells about "The Aircraft D. F. Installation"; it is as complete as possible, but in his preface the author says that this chapter "is still necessarily very curtailed. Although there has been much activity in this direction, there are few concrete designs of aircraft D. F. available for inclusion here." For this state of affairs the difficulties encountered in such installations, as well as the indifference of many airmen, are responsible.

Two more practical chapters, on "Fault Clearing and Maintenance," and "Notes on Field and Nautical Astronomy" complete the work. A bibliography of 374 references and an index are included. If anything material on the subject has been omitted it has escaped the present reviewer.



One of the Coils Tested

Coupling Methods for the R. F. Amplifier

By BERT E. SMITH

Aero Products, Inc.

WHEN the screen-grid tube was first introduced it was heralded by many as a panacea for all the ills associated with r. f. amplifiers. That such is not the case is becoming more and more evident. The tube undoubtedly is valuable, but just what can be expected of it can be determined only from the data obtained from carefully done laboratory investigations. In this article is presented some such data indicating the comparative gain and selectivity that can be obtained from the tube when it is used with different types of r. f. transformers.—THE EDITOR.

FOR several years the development of radio-frequency amplification has been practically dormant, with little, if anything, new in sight at the present time. Recent improvements have been confined to the sonic end of the receiver, with the result that radio has been lifted from a fad to an art, but the old thrill of "distance" has passed! No longer do eager commuters rush for the morning train to brag about the dx of the night before, and no longer do "Radio Widows" get divorces because their husbands desert them to spend the nights with the radio set and the thin elusive signals from a transmitter three or four thousand miles away.

For, strangely, in spite of the fact that receivers now average six or seven tubes where they used to have perhaps three, and broadcasters use ten or a hundred times their former power, it is harder and harder to get distant stations.

Many theories have been advanced to explain this, but in the final analysis, it becomes increasingly evident that the truth must be that in the rush for selectivity and quality, designers have lost sight of sensitivity. The science of radio-frequency amplification has seen retrogression rather than progress. Nothing of any real value has been introduced since the Hazeltine neutrodyne system several years back, and even that, insofar as the principle of neutralization by external capacitative reactance is concerned, was only a variant of the earlier Rice system.

In the years immediately following the introduction of the neutrodyne, many schemes have been advanced purporting to produce the full theoretical amplification of the tube and transformer, or to enable the tubes to be stabilized without any loss of efficiency, but all have proven impractical, and 100 per cent. efficient radio-frequency amplification continues to be a vainly sought chimera. A surprising number of manufacturers have returned to the oldest method of stabilizing known—potentiometer grid control. Some are cutting down the plate voltage applied to the tubes. Some use variable leaks across the tuning condenser, broadening the tuning and losing all the well known advantages of low-loss coil and condenser construction. Practically every manufactured receiver to-day on the market employs one of the "losser" systems which were so violently, although justly, condemned a few years ago!

Small wonder, then, that receivers do not reach out for distance now as then!

That there is still a call for sets which will bring in distant stations was distinctly evidenced by the sudden rush when the screen-grid tube was announced, and it is decidedly unfortunate that this tube was heralded by so much misleading publicity, which led builders to expect much that has proven impossible. Many of the leading publications carried editorial matter describing the great amplification obtainable from a tube which would not oscillate, and even the largest tube manufacturers and best engineers in the country allowed statements to appear such as "a voltage amplification of 200 per stage is obtainable, but at broadcast frequencies the resonant impedance is lower reducing the amplification by 25 per cent. of this value."

It may be possible to get such gain from the tube in laboratory apparatus, constructed by competent engineers, and under ideal conditions, but performance of this kind cannot by any means be secured from the ordinary broadcast receiver. It has become extremely doubtful, in the writer's opinion, whether the tube in ordinary use in tuned radio-frequency receivers operating at frequencies of 500 kilocycles and higher can produce great deal better all around results than the 201A type tube which has been standard for so long a time.

With all these facts firmly in mind, an investigation was recently undertaken with the object of determining two things: First, whether some existing method of stabilization could not be so modified as to give really passable results by permitting r.f. amplifiers to be built without the intentional introduction of losses except as desired for a volume control; and secondly, whether this amplification might be obtained within appreciable limits of selectivity, regardless of the type of tube used. However, all the tests described below utilized the 222 type of tube. No new ground was gone over, and nothing was developed which did not bear out previous empirical design, but there had been so much theoretical data published, and so little of the results of actual quantitative tests, that it seemed that figures obtained through concrete experimentation might be at least refreshing.

Prior to commencing any actual work, certain limits were laid down as essential if the results were to be of any value in designing a receiver which could be constructed by the kit builder. First, standard apparatus, obtainable by anyone, must be employed. Second, the need for any complicated balancing, by means of expensively accurate apparatus after construction, must be avoided if possible. Thirdly, the use of shielding, while not barred, was considered undesirable as introducing superfluous expense and trouble. Last, no involved or critical adjustments of any kind were allowable, as a receiver must be infallibly sure to give good results if the connections are properly made, in the hands of the most inexperienced operator.

THE TEST OF COUPLING METHODS

THE first actual operation was the determination of the method of coupling tubes, and the optimum values to be used in the coupling device. For this the set-up shown in Figure 1 was utilized originally, but since the conditions in the grid circuit of the amplifier tube were not identical with those which would be encountered in actual practice, it was found advisable to add a second stage, coupled to the grid of the test stage tube by a special radio-frequency transformer having an absolutely flat amplification-against-frequency characteristic. The use of this stage allowed the test stage to be adjusted to operate in a manner exactly identical with its performance in an actual receiver, permitting oscillation to take place in the same way and at the same point. The output of a modulated oscillator, variable in frequency over the broadcast spectrum, was led through an adjustable attenuator to the grid of the first amplifier tube,

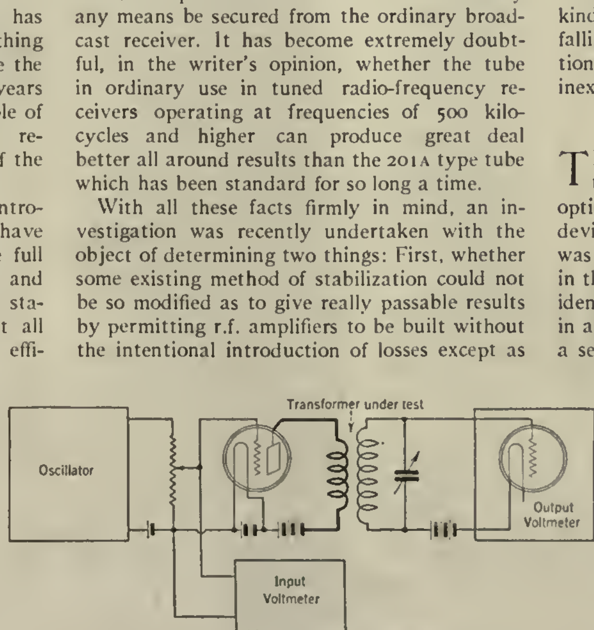


FIG. 1

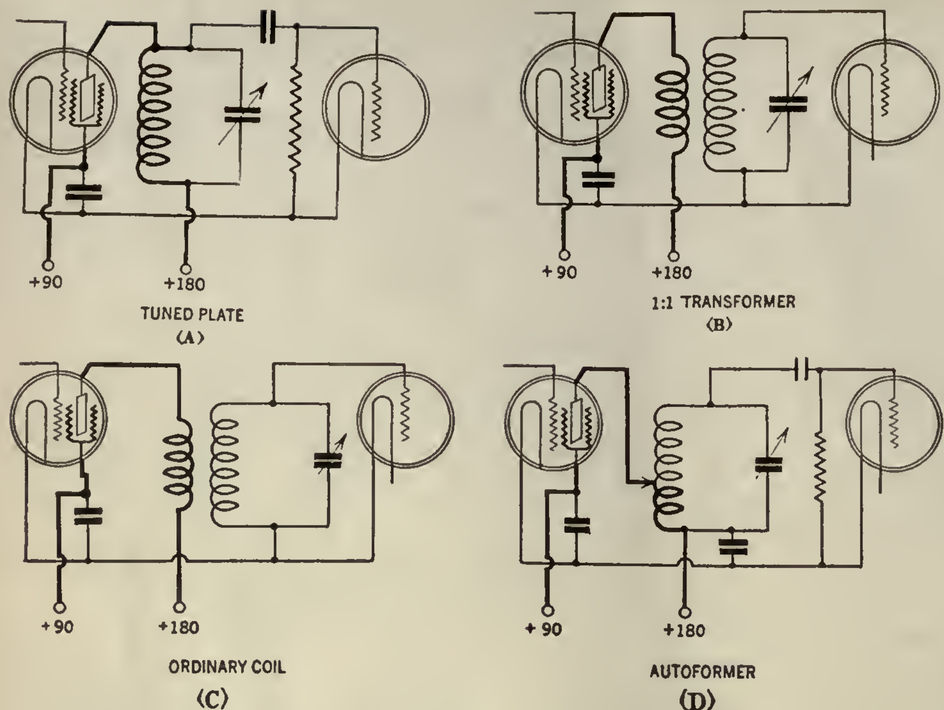


FIG. 2

also actuating a very sensitive vacuum tube voltmeter. By this means the input signal could be kept constant regardless of frequency variation. The output of the coil under test was led to a second vacuum tube voltmeter whose input characteristics were similar to those of a typical detector circuit. A second transformer, having the same flat amplification-against-frequency characteristic already mentioned, was used as a standard of comparison for plotting figures of merit on all couplers used.

This test was given to coils of sixteen types, as many of each type being tried as were deemed necessary to determine their worth. Inasmuch as the reproduction of all these curves here would only lead to confusion, due to their number, and would serve no particularly useful purpose, we will show the results obtained in those most usual types which had a bearing on the final result. However, as a matter of information, it may perhaps be advisable to outline roughly the types involved and the major reason for their abandonment.

All coils were of the general type illustrated in the photograph on page 361, having 77 turns of wire in the secondary circuit, air-spaced to conform to an approach to the ideal shape factor and supported by a skeleton bakelite frame, so that the insulation losses are kept at a minimum figure. The self-inductance of the secondary alone was 167.4 microhenries and the radio-frequency resistance of the coil in series with a Cardwell condenser varied from 3.85 ohms at 550 meters to 9.6 ohms at 200 meters. These figures are meaningless in direct relation to almost all of the actually tested coils, as the introduction of a primary coil, or the use of a portion of the secondary coil for coupling, have a decided effect on both the inductance and the high-frequency resistance of the secondary.

Among the types tested were:

1. A tuned impedance, directly from plate and grid to ground. Fig. 2–A.
2. An auto transformer, in which a portion of the secondary is used as primary, the low potential ends being common. Fig. 2-D.
3. A transformer in which the primary and secondary are coupled by a bypass condenser at the low potential ends, the direction of the winding being continuous from plate to grid, and the coil being tuned from plate to grid, as in the R. B. Lab. circuit and Betts circuit adaptations.
4. A primary wound to take up a length of $1\frac{1}{2}''$, inside the secondary. Fig. 2-B.
5. A primary wound to take up $\frac{1}{2}''$, placed inside and in the center of the secondary.
6. A primary wound to take up $\frac{1}{2}''$, placed inside and opposite the low potential end of the secondary. Fig. 2-C.
7. A primary wound with a length of $\frac{1}{8}''$, placed in both positions above described.
8. A primary wound in a $\frac{1}{32}''$ slot, coupled adjustably to the secondary.
9. A primary wound on the same diameter as, and at an adjustable distance from, the secondary.
10. A tuned primary with adjustable coupling to the secondary.

Each was tested with a varying number of primary turns, and where possible, with varying degrees of coupling, as well as with primary windings in both directions in the first few tested. Empirical analysis previous to the test had led us to believe that where capacitative coupling existed between the plate circuit of the preceding tube and the grid circuit of the following tube, the voltage in the secondary due to this coupling would be in quadrature with that generated by the inductive coupling when the winding was continuous in direction from plate to grid, and hence would reduce the amplification obtainable, although probably flattening the curves somewhat due to the change in relative energy transfer by capacity and inductance at varying frequency. This was borne out in the first few curves, and since the object of the test was to secure the highest possible amplification throughout, the balance of the tests was made entirely with the windings in opposite directions.

RESULTS

IN FIG. 3 curves of amplification are shown on three windings in types 2, 4 and 6, and will be discussed at more length later. Type 1, illustrated in Fig. 2–A, generally advocated for use with the screen-grid tube, showed no greater amplification than several other types, and was pronouncedly poor in selectivity. Type 3 gave beautifully flat curves, but the amplification was low, as only a portion of the built up voltage was impressed across the grid and filament of the following tube, and the selectivity was rather poor. Types 7 and 8 appeared desirable from some angles for particular purposes, but in general were not considered as useful as the standard types. Due probably to the large distributed capacity of this type of winding, decided resonance peaks were obtained which varied in their amplitude with the degree of coupling and number of turns used. When a coupling was adjusted to the optimum degree where only three peaks were observed in the broadcast spectrum and a merit figure of $4\frac{1}{2}$ to $5\frac{1}{2}$ was obtained, the selectivity was very poor, and when either coupling or self-inductance was so adjusted as to allow appreciable selectivity, variations in amplification as high as 50 per cent. were unavoidable. It seems therefore evident that this type of winding is not as a rule desirable. Type 10 gave extremely good results, but was impractical for use in receivers because each stage would require three controls, two for tuning and one for coupling, each of which required adjustment for every frequency change.

Types 4 and 6 are very commonly used, and hence we have selected them for detailed presentation in connection with type 2, which was finally adopted as best. Type 4, illustrated in Fig. 2–B and generally advocated for use with the screen-grid tube when the tuned impedance arrangement is not employed, is shown on the chart of Fig. 3 in dot-dash lines, and it will be noted that after the number of turns increases to a certain point, no further increase in amplification is obtained, and hence the 1:1 ratio which has been recommended is not only unnecessary, but undesirable, since the selectivity, poor at all times with this type of construction, is very bad when more than eighteen turns are used.

Type 6, illustrated in Fig. 2–C, is the type most commonly used at the present time and the results indicate that if conventional circuits are to be employed, it is considerably superior to any of the others tried. It is at least as good in amplification as the widespread primary, with

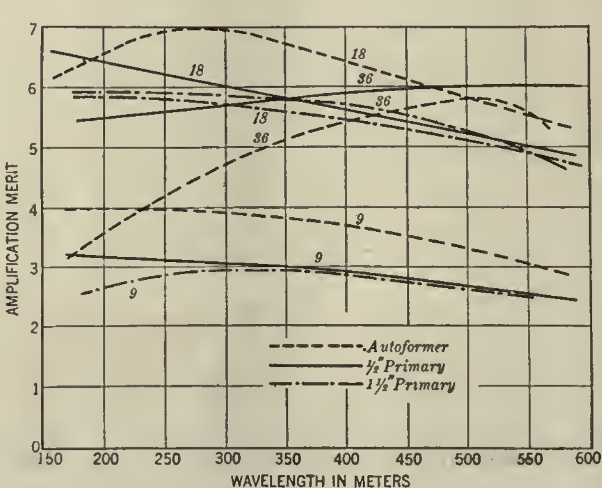


FIG. 3

The numbers on the curves refer to the number of turns used in the primaries of the coils that were tested

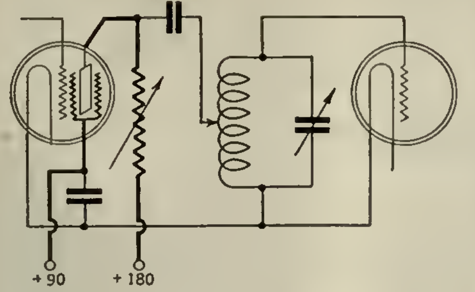


FIG. 4

a considerably improved selectivity factor. It will be noted in Fig. 3 that a variation in the number of turns results in a change of the point where maximum amplification is secured, and hence in a multistage cascade amplifier where selectivity in one or two stages may be sacrificed, comparatively uniform amplification can be secured over the whole band by adjusting the number of turns in the primary of each transformer.

Results obtained from type 2, illustrated in Fig. 2–D, are of extreme interest. In this type of coil a varying portion of the secondary acts as primary, with the primary and secondary currents in this portion of the coil in quadrature. The inductive coupling for the same number of turns in the primary is much greater in this type of coil, hence a comparatively high plate circuit impedance is built up with a relatively small number of turns, with consequent greater overall amplification. It will be noted in Fig. 3 that when many turns are used as primary, the amplification on the shorter wavelengths is reduced, because the portion of the coil in which the currents are in quadrature is appreciable and hence the voltage at the grid of the following tube is lower. This can be put to good use in a multistage amplifier to secure substantially uniform amplification over the whole spectrum. The selectivity of this arrangement compares very favorably with all of the types tested, and is pronouncedly superior to both the more or less commonly used types directly compared.

In the selectivity curves shown in Fig. 6, a selectivity factor of 50 is fair, 55 is good, and 60 is an extremely desirable value. At 350 meters this selectivity figure can be obtained with the autoformer circuit with an amplification figure of merit of 5.7, whereas with the $\frac{1}{2}''$ primary corresponding selectivity is secured with an amplification of only 3. 6, or about 65 per cent. In this particular instance the superiority of the autoformer type is very outstanding.

As shown in Fig. 2–D the autoformer circuit is not very practical due to the high potential (d.c.) of the tuning condenser. The circuit of Fig. 4 retains the advantages of the coil construction while eliminating this drawback.

OSCILLATION CONTROL

UP TO this point no mention has been made of oscillation. Depending upon the tube used and the constants of the circuit, this was frequently encountered, even with the screen-grid tube, unless some means were taken to prevent it. In this connection, it must be borne in mind, in analyzing the results obtained, that they only hold good in a circuit carefully adjusted in such a way that oscillations cannot take place.

A review of various methods of stabilization indicated that the best results were probably obtained by shifting the phase angle of the currents in various stages, by a method somewhat similar to that illustrated in Figure 4. Here in the plate circuit, we have one branch consisting of resistance only and another of capacity and inductance in series, the latter value depending upon where the tap is placed on the tuning coil.

By varying the resistance, it is possible to change the angle by which the current leads the voltage in any one stage, and in this way control the tendency towards oscillation. Unfortunately, however, when resistances of the proper value to give us adequate control of the phase angle are employed, it will be found that any variation of the resistor varies the plate voltage applied to the tube and may seriously affect the amplification obtainable. In order to avoid this, the circuit shown in Fig. 5 was finally adopted. The r.f. choke, L_2, having a comparatively low d.c. resistance, was shunted around the resistance, maintaining a maximum static value of plate voltage at the tube, while offering a very high impedance to radio-frequency currents. The resistance, R_1, can now be varied without affecting the static value of the plate voltage and will be found to serve very nicely as an oscillation

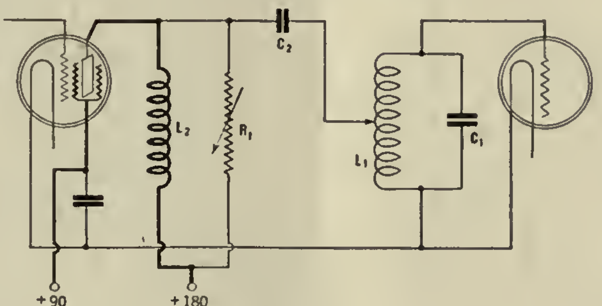


FIG. 5

control; and if it can be reduced to a low value, so as to effectively short circuit C_2, it can also be employed as a volume control for the receiver.

In a circuit containing two stages of r.f. amplification, it will rarely be found necessary to employ more than one such resistance, as sufficient adjustment can be obtained to avoid oscillation while still maintaining a satisfactory value of overall amplification. Maximum results, regardless of the type of tube used, can be obtained by varying the proportion of L_1 which is used in the plate circuit of the preceding tube. Little trouble was experienced from inductive coupling between coils, provided a distance of at least 6″ was between coil centers. Fig. 7 shows the coupling between two secondaries of the type used, having parallel axes.

Shielding always introduces certain losses in the coil, and also complicates the mechanical construction of the receiver. It will be seen from the curve in Fig 7 that the necessity of shielding is mitigated as far as inter-stage coupling effects go, while the diameter of the coil is so small that direct pick-up from local stations is reduced to a minimum.

In the interest of compactness, a trial was made of another method of mounting the coils where three or more tuned circuits existed. The coils were mounted comparatively close to each other but in such positions that their fields were

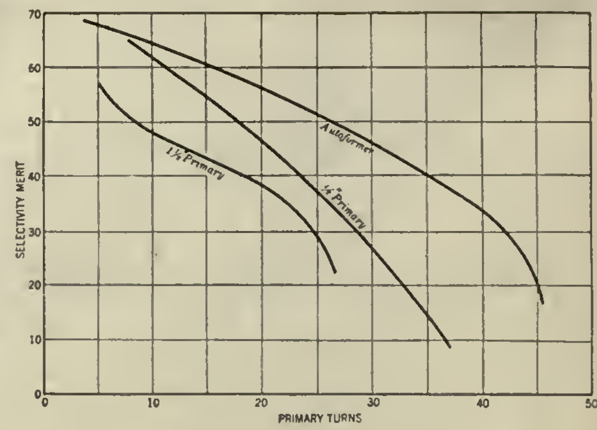


FIG. 6

opposed. It will be recalled that this "sacred angle" construction was used in practically all of the earlier neutrodynes. While placing the inductances at such an angle that the magnetic fields of several coils intermingle the least, gives some relief against unwanted coupling of this type, at the same time the coupling due to the capacity then existing between coils vitiates the most of the benefit theoretically secured.

When the coils were placed sufficiently close to secure any advantage from compactness, capacity coupling was encountered to such an extent as to destroy completely any possible advantage to be gained from this method of mounting. In addition, the length of grid leads required was in excess of a passable figure, and consequently the scheme was abandoned.

The next portion of this article will describe the construction of a receiver using two stages of tuned radio-frequency amplification with screen-grid tubes employing the "Chronophase" system whose final evolution is pictured in Fig. 5. The particular receiver in question has fully justified the long period of experimentation preceding its actual construction and will be found both in sensitivity and selectivity to be superior to most receivers with one or two additional stages of radio-frequency amplification. On a 25-foot antenna located on the shore of Lake Michigan, in the heart of the most congested mass of broadcasting stations in the world, it has been possible to cut through locals and secure good loud speaker reception of stations a thousand miles distant.

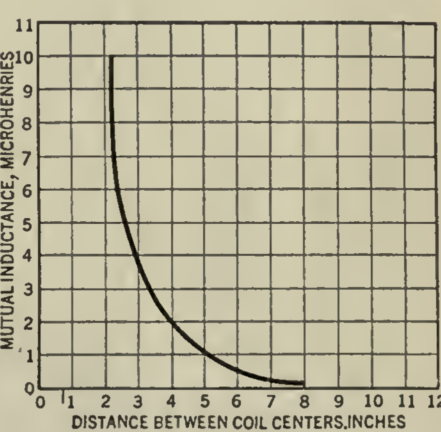


FIG. 7

"Our Readers Suggest—"

OUR Readers Suggest" is a clearing house for short radio articles. There are many interesting ideas germane to the science of radio transmission and reception that can be made clear in a concise exposition, and it is to these abbreviated notes that this department is dedicated. While some of these contributions are from the pens of professional writers and engineers, we particularly solicit short manuscripts from the average reader describing the various "kinks," radio short cuts, and economies that he necessarily runs across from time to time. A glance over this "Our Readers Suggest" will indicate the material that is acceptable.

Photographs are especially desirable and will be paid for. Material accepted will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas.

—THE EDITOR.

Obtaining Screen-Grid Bias

FOR the most efficient operation of screen-grid receivers a positive bias on the screen grid is required. Few power units designed prior to the introduction of the 222 tube provide the proper screen voltage. By means of a Duplex Clarostat, connected as a potentiometer between the negative and plus 90 volt posts on my power supply set, I am able to secure the best biasing potential. The circuit is simple and is shown in Fig. 2. Both adjustment screws should be given about two and a half turns up (from a tight adjustment) and then the lower screw adjusted until signals are amplified most efficiently. The bias potential should be bypassed with a 1.0-mfd. condenser, indicated in dotted lines in Fig. 2.

A. R. COATES, New York City.

Testing for Soft Tubes

IT IS the general custom to test for a "soft" tube by operating it under an excessive plate potential. The blue haze, caused by ionization, is an indication that the tube is soft. Unfortunately, a test of this nature often changes the characteristics of the tube, occasionally lessening the efficiency of what otherwise would be a good detector.

A perfectly safe test, more compatible with the tenets of laboratory procedure, may be effected with a small spark coil, such as that employed in the Ford, Model T, ignition system. If one of the secondary terminals is not already wired to the primary (as is the case with the Ford coil), make this connection, using a couple of dry cells to energize the primary. Take the tube in hand, covering the glass as much as possible, and touch any of the terminals to the high tension lead from the coil, watching the while for glow. No sign of ionization indicates a hard tube—or one full of air. In this latter case, of course, the filament would burn out when connected across the usual battery circuit.

A pale greenish glow, close to the inside surface of the glass, indicates about the right amount of gas for a good detecting tube. If the glow is purple, and is confined to a small area directly around the plate and filament, the probability is that there is too much gas for efficient detecting action.

ALFRED A. GHIRARDI, Stapleton, N. Y.

A Power Unit Voltage Divider

THIS department has published, from time to time, contributions describing various home constructed voltage divider systems and other devices for the improvement of power units designed prior to those incorporating more modern apparatus. Several of these arrangements have provided for C-bias potentials.

The circuit of a compact voltage divider unit, recently placed in the market by Electrad, is shown in Fig. 1. The various resistors incorporated in the unit are all variable, providing for any desired seven positive and negative potentials within the limits of the power supply output.

The "Truvolt" divider may be incorporated in the output circuit of a new power unit or used to provide special potentials from a ready-built supply unit.

Noisy reception can often be traced to disintegrating resistors in the voltage distribution system of a power supply device, a difficulty that is readily eliminated by substituting the Electrad divider unit for the original resistor system. The old resistors should be removed and the divider connected between the points of the highest potential, i.e., between the highest B voltage post and B negative or the highest C bias terminal, if such is provided on the power unit, Terminal 1 on the divider is connected to the high voltage side of the line, and Terminal 7 to the low voltage side.

Each potential secured from the divider should be bypassed with a 1.0-mfd. condenser to the post used as B negative, as suggested by the dotted lines in Fig. 1, which shows the terminal arrangement for the potentials generally required. However, the divider can be connected to the receiver in many ways to secure practically any voltage distribution.

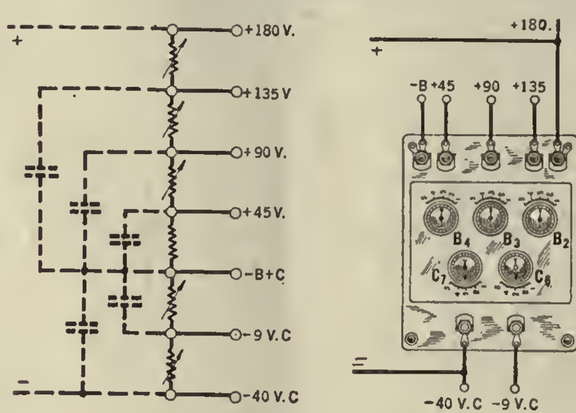


FIG. 1

The circuit arrangement of the Truvolt divider. This unit can be used for the rejuvenation of old power supply sets as well as in the construction of modern designs

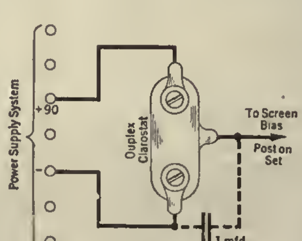


FIG. 2

A simple way of obtaining the correct positive bias for the screen grid on a screen-grid tube. This bias varies with circuit, tube and available control grid bias

Matching Condensers and Coils in Tandem Tuned Circuits

WHILE the general procedure for matching isolated coils and condensers is fairly well understood, I have never read anything on the process involved in matching coils and condensers already connected in a receiving circuit. The following system will be of value to the experimenter who desires to match an r.f. tuning combination more closely than can be done by the trial and error method on a station.

The method employs an oscillator with a meter in the plate circuit to indicate resonance. It is not essential to know the wavelength to which the oscillator is tuned, as long as it is within the broadcast band. Fig. 3 shows a circuit that can be employed as an oscillator. The number of turns of wire wound on a $3\frac{1}{2}''$ winding form is indicated on the diagram. The size of wire is not important.

The additional materials are about three feet of rubber covered wire and a small clip facilitating a temporary connection to the grid side of the circuit being tuned. Cut the wire in half and twist two ends of it together for about one inch, making a small condenser. One of the two remaining ends is soldered to the clip and the other to the grid terminal of the oscillating tube.

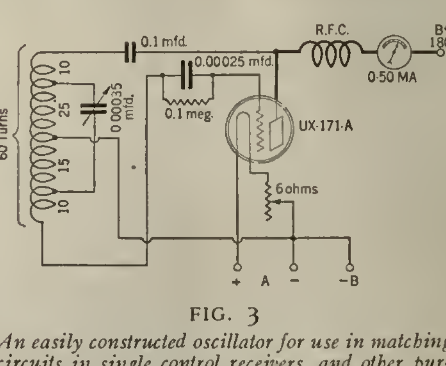


FIG. 3

An easily constructed oscillator for use in matching circuits in single control receivers, and other purposes. Any one of the several oscillators previously described in RADIO BROADCAST *may be used*

The procedure is as follows: Have the condenser sections of the combination to be matched half way out. (If the condensers are to be matched with the aid of trimmers, the trimmers also should be at half maximum capacity.) Start the oscillator and snap the clip to the grid side of one of the condensers. Tune the oscillator to resonance, which will be indicated by a maximum dip on the meter. If the dip is too broad, reduce the capacity of the twisted rubber-covered wire—by cutting down the overlap—until a sharp dip is obtained.

Snap the clip on the next condenser, and adjust this to resonance (without touching the oscillator adjustment) either by use of the trimmer, or by tapping the plates into place. At maximum deflection the two stages are in resonance with each other. The procedure is the same for additional circuits.

John Benedict, Maspeth, L. I.

An Amplifier Kink

HAVING an occasion to revamp an old set for a friend of mine, I used the audio-frequency arrangement shown in Fig. 5. The Thordarson 3½:1 transformers, originally supplied with the set, were merely rewired to conform with the diagram.

The tone quality was considerably improved, particularly on the lower register. I effected still further improvement by the use of 112A tubes in the detector and first audio sockets.

Edwin M. Wright, Phila., Pa.

STAFF COMMENT

THE arrangement suggested by Mr. Wright emphasizes the low notes. Reproduction of the higher notes can be enhanced by the substitution of a 30-henry choke for the 50,000-ohm resistor in the plate circuit of the first audio tube.

Dynamic Speaker Field Supplied from B-Power Unit

IT IS possible to excite the windings of several of the d.c. type of dynamic loud speakers from the plate current to a receiver operated from a line power supply source. It is merely necessary to connect the excitation windings of the loud speaker between the choke coil nearest the output of the socket power unit and the maximum voltage post. The connection is broken and the circuit recompleted through the windings, care being observed to connect the positive loud-speaker post to the choke coil. The current drain to the receiver should be in the neighborhood of 100 milliamperes. This, however, is generally the case where a dynamic speaker is justified.

A. V. Svenosen, New Zealand.

A Simple Audio Channel Equalizer

I HAVE found several sets in which the combination of a good audio channel and a good speaker gives an overemphasis to the low notes. I find that the addition to the usual choke output device suggested diagrammatically in Fig. 4, is most effective in controlling the amount of low-frequency reproduction.

The 0.006-mfd. condenser bypasses the high frequencies anyway, and varying the 100,000-ohm resistor (a Pilot Resistograd) adds the low notes to taste.

H. D. Hatch, Wollaston, Mass.

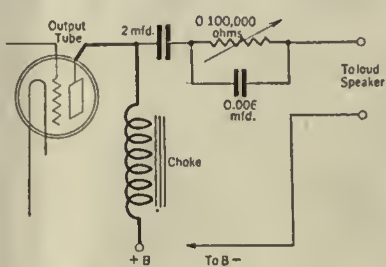


FIG. 4

A simple equalizing arrangement that controls the reproduction of low notes. This device will eliminate the "boom" in many modern speaker-amplifier combinations

STAFF COMMENT

MR. HATCH'S idea should prove most effective in eliminating the "boom" experienced with many cone and airplane cloth speakers.

A. C. Tube to Reduce Microphonics

MANY battery-operated receivers, the operation of which is characterized by excessive microphonic disturbances, can be improved by the substitution of a UX-227 a.c. tube in the detector socket with the proper filament resistor to permit its operation from a 6-volt battery.

Previous to making the suggested change, enjoyable reception from the writer's battery-operated set was practically impossible. Footsteps in the room, or the passage of a truck in the street, was sufficient to set up ringing microphonics in the loud speaker.

Appreciating the fact that the rigidity of cathode structure in a.c. detector tubes tends to reduce the vibratory motion responsible for microphonics, I replaced the UX socket in my receiver with a 5-prong socket, wiring a 6-ohm rheostat in series with the filament circuit. The cathode is connected to the positive filament terminal on the socket—that is, "C" and plus "F" are strapped together. A UX-227 tube can now be used as a detector. If the time lag—30 to 40 seconds—is objectionable, an Arcturus type 127 tube can be used instead. This latter tube "comes up" in about seven seconds.

STAFF COMMENT

THE Editor of this department has done considerable experimenting with the use of heater type tubes in airplane receivers, where they are very effective in the reduction of microphonics.

If the reader does not care to change the socket in his receiver, an Arcturus type 171 tube can be plugged into the detector socket, without making any changes in the receiver at all. No additional rheostat is required for this 5-volt tube.

An Antenna Booster For Loop

I HAVE a loop-operated set which is badly shielded by surrounding walls. To correct this I am using an outside antenna inductively coupled to the loop by means of a coil. The coil is placed inside the loop and connected to the outside antenna and to the ground.

I am using a 3" coil with 50 turns of No. 20 wire. I find that by tapping this coil in four places, that is, every ten turns, the reception is greatly improved over the entire range of wavelengths. That is, on short waves the 10-turn tap is just right while on long waves 40 turns or 50 turns is about right, with proportionate taps in between.

William D. Esch, Cherryvale, Kans

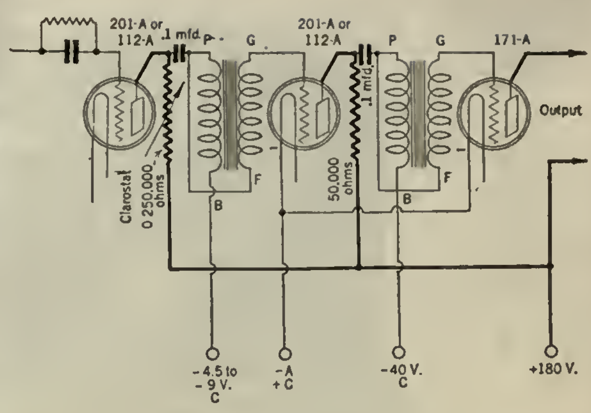


FIG. 5

Rearranging an old amplifier in accord with this circuit will give fine quality even with poor amplifying transformers

STAFF COMMENT

AN ARRANGEMENT practically identical with Mr. Esch's suggestion was described in this department for December, 1927, and January, 1928. A commercial coupling coil for this purpose is made by the Jenkins Radio Company of Davenport, Iowa.

An Output Filter Without a Condenser

A VERY effective output device for use with the average receiver may be made with the use of a choke only (the condenser being omitted) providing the characteristics of power tube and speaker are known so that the proper choke may be employed.

In a receiver constructed by the writer, a 171 type tube was used in conjunction with an R. C. A. 100 speaker, which is comparable in characteristics to most cone reproducers. A condenser of sufficient capacity not being available, the speaker was connected in parallel with a 25-henry choke as shown in Fig. 6-A. The equivalent circuit, based on a frequency of 100 cycles, is shown in Fig. 6-B. At this frequency the impedances are, approximately: tube—2000 ohms, choke—15,700 ohms, and speaker—2000 ohms. The d.c. resistance of the choke is 600 ohms and that of the speaker is 1800 ohms.

It will readily be seen that the speaker, being of rela ively low impedance, will take about 90 per cent. of the a.c. current, but due to its high resistance, compared to that of the choke, will allow but one third of the d.c. current to pass. This will be in the neighborhood of 6 milliamperes, which is not objectionable. The resistance of the plate circuit is considerably lower than that of the actual output device, and hence the voltage drop will be smaller.

The quality of reproduction, using this combination, was found to be excellent.

Glenn R. Taft, Ticonderoga, N. Y.

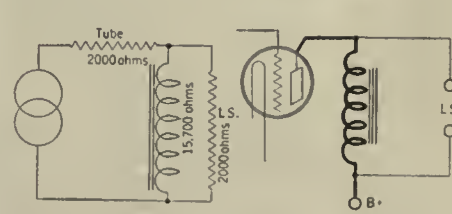


FIG. 6

An output device using a choke coil without the conventional condenser. The wiring circuit is shown at A, and at B is the equivalent schematic circuit

The Receiver Combines Simplicity and Beauty

The "Vivetone 29" Receiver

By R. F. GOODWIN

THE receiver which Mr. Goodwin describes in this article is a t.r.f. set which performed in the Laboratory in a fashion to indicate that its designer is not prone to exaggeration. There are several novel features; one is an automatic regeneration control, consisting of a resistor which changes its value as the set is tuned, thus adjusting the C bias on the r.f. tubes and keeping them from oscillating at any dial setting. Another is an a.c. voltmeter which is mounted on the panel so that the operator can tell at all times the voltages across his tubes. If the constructor builds one of the amplifier-power supply units the author has developed, he will have in it a regulating device which will enable him to keep this voltage at its proper value regardless of line voltage fluctuations.

—THE EDITOR.

SENSITIVITY, selectivity, quality of reproduction, beauty in appearance, and simplicity of operation—these are the five paramount requisites of a modern receiver. Every discriminating radio constructor or enthusiast must consider each of these features separately and in connection with each other when he decides what receiver to build, buy, or operate. Some of these features are often secured at a sacrifice of others; as in other phases of life one cannot get something for nothing.

The "Vivetone 29" is a receiver in which the effort has been made to incorporate all these features to as high a degree as possible without too great a compromise. In other words, it embodies a circuit that has considerable radio-frequency gain, that is simple to operate—there are only two controls—and yet is sufficiently selective to cope with modern broadcasting conditions. More will be said about the sensitivity and selectivity later when the writer describes his own success with the receiver in a location which is none too good for dx reception. It is enough to state now that the selectivity is sufficient to enable one to tune through many local stations with a minimum of interference, and that the sensitivity is such that distant stations can be picked up with a great deal of ease.

DESIGN FEATURES

THE fact that the set contains three stages of r. f. amplification, each separately shielded and constructed of the best "low loss" apparatus now on the market, may account to the technical reader for the set's gain. With the addition of the detector input, which is tuned, the receiver has four tuned circuits, each working with a minimum of regeneration so that the order of selectivity is rather high.

There are two novel features, one of which has not been seen heretofore so far as the writer is aware, and the other—an a. c. voltmeter on the panel—is omitted from the vast majority of otherwise well designed sets. The novel feature which impresses the writer most is a simple but effective method of automatically controlling the regeneration in the r. f. stages. This is done by automatically varying the bias of the grids of the r. f. tubes as the set is tuned to various frequencies.

It is well known that all t.r.f. receivers tend to oscillate badly on the high frequencies (shorter wavelengths) and that many such receivers have included in their mechanism a resistor which changes the plate voltage, or C bias, of the r. f. tubes so that actual oscillation does not take place. Such devices are always manually operated, so that at each setting of the tuning condensers it becomes necessary to adjust the regeneration control—often labelled a volume control—to the point of best operation.

In this receiver all such adjustments are made automatically by attaching a 2000-ohm variable resistance, PP-2000 in Fig. 2 and 3, to the shaft of the tuning condensers. It is so adjusted that as the tuning condensers are varied the bias is reduced at the lower frequencies and increased at the higher frequencies. This has the same effect as changing the plate voltages to these tubes, but in the writer's experience is a neater method of accomplishing the same result, i. e., the maintenance of greater stability as a whole.

In addition to the automatically changing resistance, another resistance is shunted across the bias adjuster for fine adjustments. This resistance, PP-5000, is located on the panel so that manual regulation may be had when desired. It must be understood that it is not necessary to change the setting of this resistance at all for ordinary operation, but when one is dx hunting he often needs just that small additional control which "brings 'em in."

On the panel is an a.c. voltmeter which, after the receiver has been placed in operation, is permanently connected across the heater element of the detector tube. It shows the voltage across that tube at all times, and since this tube in common with all the others is fed from a filament supply transformer the meter's indication tells what the general voltage conditions are. The writer has developed a series of power units for this receiver in which are incorporated voltage regulating devices. It is a simple matter, then, to keep the voltages across the filaments and heaters of the tubes at the proper value at all times.

If the receiver is operated with another power device in which there is no provision for voltage adjustments, the operator may obtain such regulation by placing a power resistor in series with his power transformer primary.

AUDIO AND POWER UNITS

THE "Vivetone 29" receiver proper does not incorporate an audio amplifier, since the writer does not believe that an audio amplifier should be built in the same cabinet with the r.f. portion if the size of the set is to be kept within attractive proportions. Keeping it separate from the tuning elements of the receiver not only gives the builder a choice of audio equipment, but also permits him to have more room for the disposition of his r.f. apparatus. Space in this part of the receiver is most important when one is interested in sensitivity and selectivity.

The writer has developed two power amplifier units that can be constructed for the "Vivetone 29." One of these uses a CX-310 tube in the last stage with a Thordarson 210 power pack. This unit will be described in a later issue. Each of these units incorporates a complete audio amplifier and A-B-C-power supply. The home con-

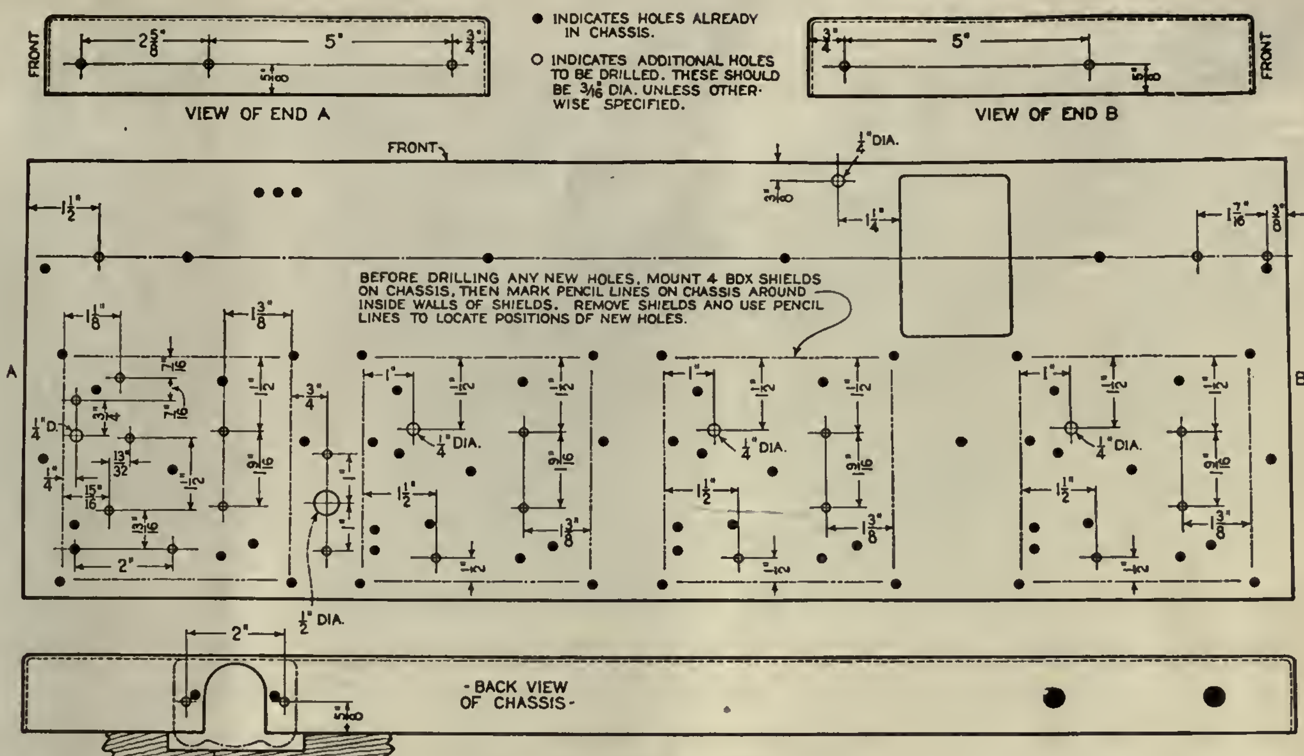


FIG. 1. THE LAYOUT OF THE CHASSIS

structor or custom set builder may choose the power supply unit that suits his pocketbook, or may pick out the one which gives the greatest amount of output power at audio frequencies. The quality of reproduction that is obtainable from the receiver with either of these units or with any good amplifier and power equipment is comparable with the best receivers on the market to-day.

The tuning equipment illustrated and described here can be used, of course, with any amplifier. The output of the detector may easily be placed on an amplifier of any number of stages or of any type of coupling devices. With the advent of the newer power tubes, the constructor is advised to go in for the best he can afford, since a receiver made of the best apparatus now purchaseable should be able to stand up in comparison with the receivers to be designed and built for several years to come. In other words the best possible receiver and power equipment is, in the long run, the most economical. Unlike the automobile, it does not depreciate at a very rapid rate.

The receiver is batteryless. It is entirely electrified with either of the power units the writer has built or with any power apparatus which operates from a light socket. This is accomplished by the use of 326 and 327 a.c. tubes.

CONSTRUCTION

PROBABLY the most novel part of the receiver so far as the home constructor is concerned, is that all the parts in it are standard and can be purchased at most dependable radio dealers.

The sub-base and box shields are standard products of the Aluminum Company of America and most of the holes required for mounting the parts to this sub-base have been punched in during the manufacturing process. The few additional small holes required can easily be made with the aid of a small hand drill which is most generally part of the radio technician's tool kit. Fig. 1 shows exactly where to drill these holes.

The construction of the receiver is simplicity itself, and is clearly shown in the schematic and picture wiring diagrams in Figs. 2, 3 and 4 and the panel layout in Fig. 1. Resistor PP-2000, whose variable arm is attached to the gang condenser shaft, is mounted on a brass bracket 2 1/16" high and 3/8" wide screwed to the chassis. Each of the r. f. coils, 9072, is mounted by means of two 6/32 round head machine screws 1" long, being thus raised above the chassis. Full-sized drawings and additional constructional notes on the receiver and power unit number one and number two may be obtained from the writer. To cover the cost and postage they are priced at $1.00.

It will be noted that the circuit diagram calls for grid suppressors of 400, 500, and 600 ohms for the three radio-frequency amplifiers. Decreasing the values of these resistances increases the amplification. For example, a good combination would be 300 ohms in the first stage, 400 in the second, and 500 ohms in the third. They may, however, be decreased to as low as 200, 300 and 300 for the three stages respectively. This, of course, is to be determined only by the one who is constructing the receiver, since some like to tune in stations without experiencing regeneration, while others like the "swish" of a slightly regenerative set as they go through a carrier signal.

THE CABINET

THE writer's receiver is housed in a Corbett cabinet 7" x 26" x 10" deep. The cabinet had to be prepared for its reception by cutting out holes for the cable plug and the antenna and ground connections. To have the chassis of the receiver fit snugly in the cabinet it was necessary to remove a small portion of the wood at both the front and back corners. These cabinets, however, may be secured from the Corbett people with such alterations already made.

If the constructor is careful his efforts will be rewarded with a magnificent receiver. The set can be placed on a table or in one of the special cabinets which houses the power supply apparatus in the bottom.

A model of this receiver has been in operation at the writer's laboratory for several months and its performance has given considerable satisfaction. The laboratory is located not over a half mile from

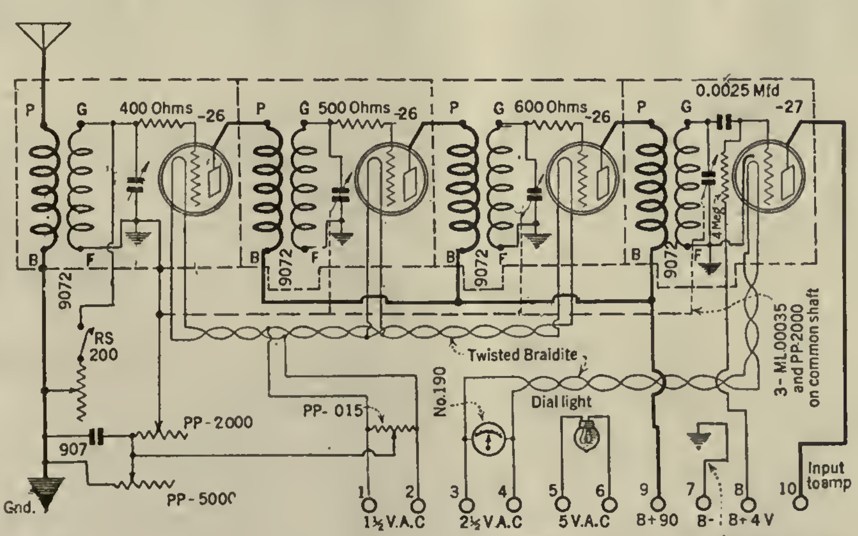


FIG. 2. THE SCHEMATIC DIAGRAM

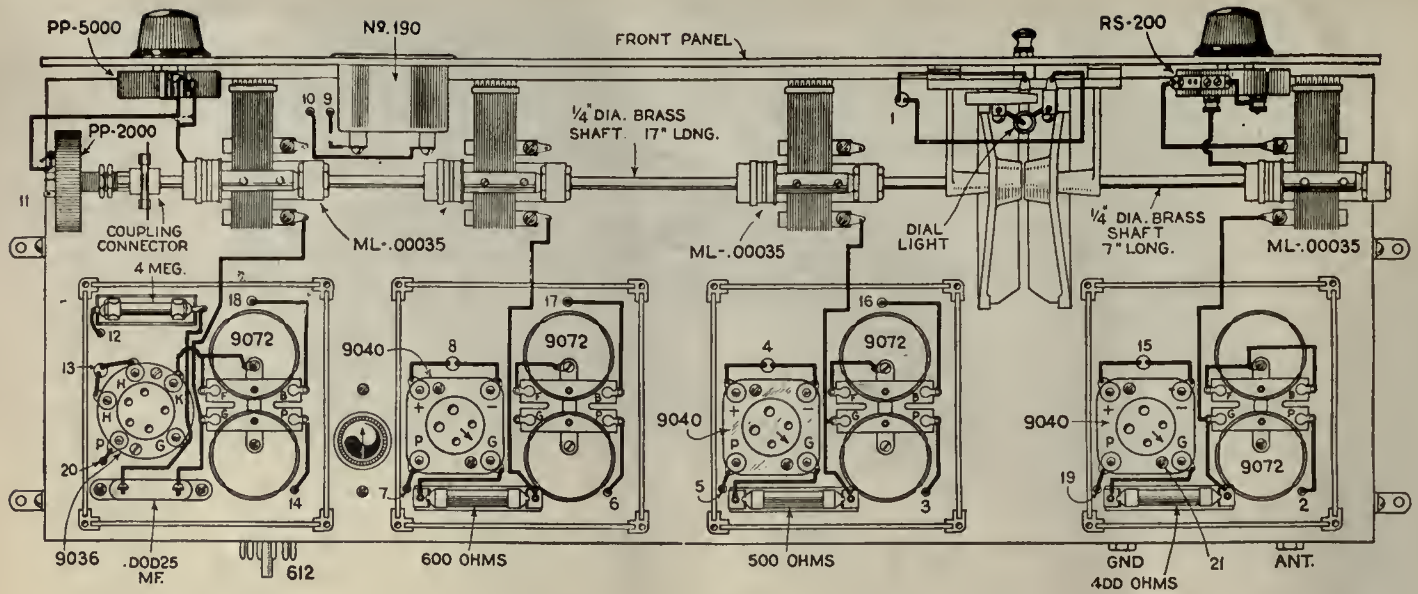


FIG. 3. INSTRUMENTS AND WIRING ABOVE THE CHASSIS

With the rotor plates of the condensers fully meshed, the position of the variable arm of resistor PP-2000, when viewed from the left end of the chassis in this diagram, should be two thirds of the way up towards the vertical on the left hand side. The coded holes in the chassis correspond to the numbers in Fig. 4.

three New Jersey stations, WOR, WAAT, and WKBO. In this location we are able to tune WEBH and WMBB in Chicago, KDKA, and several other stations within a radius of 1000 miles. On several occasions, shortly after midnight, we have listened to programs broadcast by KFI and KHJ, Los Angeles, on a loud speaker. The Chicago stations were often mistaken for local broadcasters.

All in all, the "Vivetone 29" is a receiver which is not difficult to build or operate, and which is sufficiently selective to cope with the present broadcasting situation and, with sufficient sensitivity to amplify weak signals up to the point where they can be enjoyed.

LIST OF PARTS

As NOTED above, all the parts used in this receiver are of standard design, and may be replaced by equivalent parts of manufacturers other than those mentioned below. The type numbers of the parts listed below correspond with the lettering on the diagrams.

- 4 Hammarlund variable condensers, 0.00035 mfd., type ML–00035
- 1 Dubilier condenser, 1.0 mfd., No. 907
- 1 Dubilier moulded micadon condenser, 0.00025 mfd.
- 1 Hammarlund illuminated drum dial
- 1 Pair Yaxley phone tip jacks
- 1 Centralab potentiometer, 5000 ohms, type PP–5000
- 1 Centralab potentiometer, 2000 ohms, type PP–2000
- 1 Centralab potentiometer, 15 ohms, type PP–015
- 1 Centralab switch-type Radiohm, 200,000 ohms, type RS–200
- 3 Daven grid stabilizers, 400, 500 and 600 ohms, respectively
- 1 Dubilier Metaleak, with mount, 4 megohms
- 4 Aluminum Junior box shields
- 4 Benjamin Lekeless Transformers, No. 9072
- 1 Hammarlund coupling connector
- 1 Jewell voltmeter, 0–3 volts a.c., No. 190
- 1 Aluminum shielded chassis, "Vivetone 29"
- 1 Yaxley 12-wire cable connector and plug, No. 612
- 3 Benjamin 4-prong sockets, No. 9040
- 1 Benjamin 5-prong socket, No. 9036
- 1 Micarta front panel, 7" x 26"
- 1 Corbett cabinet, 7" x 26" x 10" deep
- 1 roll solid Braidite wire
- 1 roll flexible Braidite wire
- 3 CX-326 tubes
- 1 CX-327 tube

To make the set operative either of the Vivetone A-B-C-power-pack amplifier units, or the following accessories, are necessary:

Audio amplifier of good design

Filament transformer to supply 1½, 2½ and 5 volts a.c.

Source of B power (90 and 45 volts)

C battery (—4½ volts)

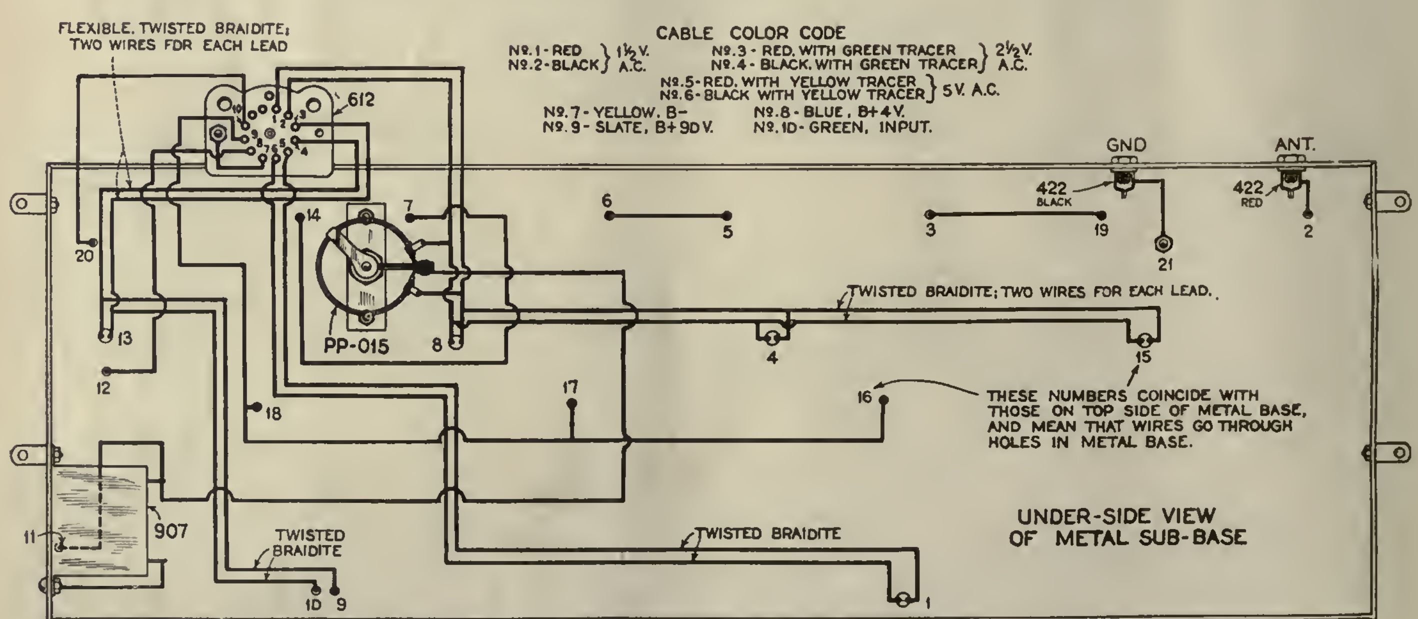


FIG. 4. THE UNDER SIDE OF THE CHASSIS

The potentiometer, PP-015, is insulated from the chassis, and its shaft should not touch the aluminum. Care should also be taken in mounting the cable plug receptacle that its position is such that none of the pins will touch the aluminum chassis.

No. 9. **October, 1928.**

Radio Broadcast's Service Data Sheets on Manufactured Receivers

The Bosch Model 28 Receiver

THIS is a seven-tube receiver employing three stages of tuned radio-frequency amplification, a detector and a two-stage transformer-coupled audio amplifier, the second stage of which is push-pull. Type 226 tubes are used in the r.f. and first a.f. stages, a type 227 tube in the detector stage and two 171A type tubes in the push-pull stage, and a type 280 rectifier in the B-power unit. The four tuning condensers are ganged to a single panel control—an illuminated drum dial. The additional controls on the front panel are a volume control and a "clarifier," which is actually a variometer with a pretty name. It tunes the antenna circuit to resonance. The volume control is a high-resistance potentiometer R_1.

CABINET MODEL 28

This receiver is designed for operation on 60-cycle a.c. lighting circuits at voltages from 100 to 130 volts, a tapped transformer primary serving to adjust the receiver for correct operation on any voltage between these two limits. A plug is used to connect to that particular tap on the transformer which gives best results. Moving the plug to the right (to the "115" or "125" socket) decreases the voltage on the tubes. It will, therefore, prolong the life of the radio tubes to operate the receiver with the switch plug in a position as far to the right as is consistent with satisfactory reception. For example, if the maximum line voltage measured is 115 volts, try the switch plug not only in the "115" socket, but also in the "125" socket as well. If the latter gives good results it will be of decided advantage to use this position, as it will increase the useful life of the tubes and reduce to a minimum the danger of burning out tubes. Do not, therefore, move the switch plug to the left in an effort to secure louder reception.

Model 28 is housed in a table mounting cabinet. Models 28A and 28B are console types. All models have self-contained power units.

TECHNICAL DISCUSSION

1. Operation.

The receiver is operated by three controls. The main tuning control serves to turn all the tuning condensers and tune in any desired station. The control is graduated into 100 divisions and after a station has been recorded, it can always be picked up at the same reading of the dial. Changes in the length of the antenna will not affect the station logging. The Clarifier is actually a variometer across the antenna and ground and is an auxiliary tuning device which brings this circuit of the receiver to the point of exact resonance. After tuning in a station with the main dial, the Clarifier should be adjusted to the point of maximum volume. The volume control adjusts the volume to any desired level.

2. Tuning System.

The r.f. amplifier consists essentially of three stages of tuned and neutralized amplification, with a variometer across the input circuit to permit the accurate tuning of this circuit to resonance. The circuits are all matched at the factory by means of the small condensers, C_1 and C_2, connected across the second and third tuning condensers. The sensitivity and selectivity of the set is improved distinctly by the use of the variometer in the input circuit.

3. Detector and Audio System.

Grid leak and condenser detection is used and a type 227 tube is used as the detector. The audio stages are transformer coupled, the second stage being push-pull. The push-pull amplifier with 171A type tubes can deliver all the volume required for home use, without any distortion due to overloading. The detector is supplied with 40–50 volts, the first a.f. amplifier with about 100 volts plate potential and a C bias of 7 volts. The push-pull tubes receive about 150 volts and a C bias of 35 volts. The push-pull tubes feed into the output transformer, T_1, the loud speaker being connected to its secondary terminals.

4. Volume Control.

This control consists of a high resistance potentiometer, R_1, connected across the input to the first r.f. tube. In this position it functions to regulate the signal energy entering the r.f. amplifier and therefore prevents tube overloading.

5. Filament Circuits.

The filament leads to the various tubes are twisted pairs of wires connecting between the transformer and the various tube sockets. The type 226 r.f. tube filaments are supplied with approximately 1.4 volts, the 227 type detector with about 2.4 volts, the first a.f. tube—a type 226—with 1.4 volts, and the power tubes with 5 volts. Resistances, R_2, R_3, and R_4, are connected across the various filament circuits for hum balance.

6. Plate Circuits.

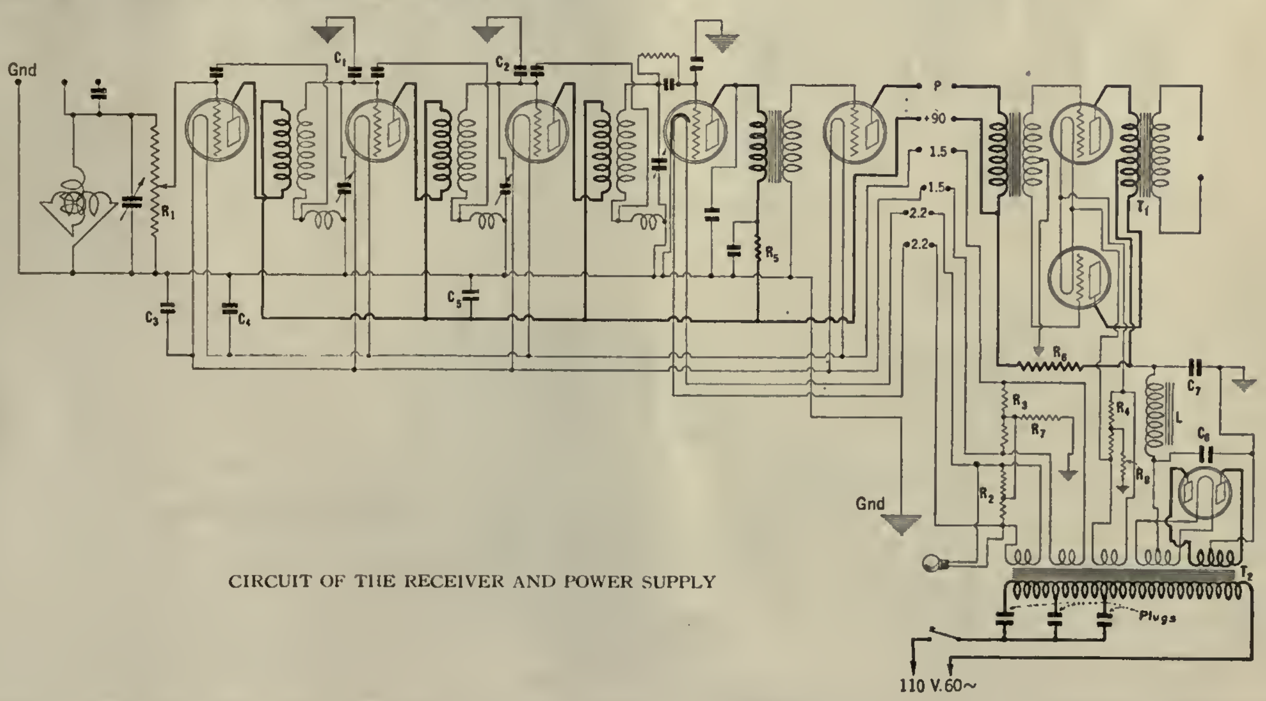
The plates of the r.f. tubes in this receiver are supplied with approximately 100 volts and the grids with 7 volts. The detector is supplied with the same voltage as the r.f. tube, but this voltage is reduced to about 50 by the resistance, R_5, in series with the plate circuit. The first a.f. tube has 100 volts on the plate and 7 volts on the grid. The power tube receives about 130 volts and the grid bias is about 35 volts. The filament circuits of the r.f. tubes are bypassed to ground by C_3 and C_4, each with a value of 0.5 mfd. The plate circuits are bypassed by the 1.0-mfd. condenser, C_5; the detector bypass condenser, C, also has a capacity of 1.0 mfd. R_6 reduces the maximum voltage to 100.

7. Grid Circuits.

Grid biases for the various tubes are obtained by connecting resistors between the center tap of the filament circuits and B minus, which corresponds to ground. Seven volts for the r.f. and first a.f. tubes is supplied by R_7 and 35 volts approximately for the grid of the power tube is obtained from R_8. There is zero bias on the grid of the detector.

8. Power Supply.

The transformer, T_2, in the power supply unit supplies low voltage to the filaments of all the tubes and the dial light and also high voltage to the rectifier system, which uses a type 280 tube in a full-wave system. A single section filter is used consisting of C_6 L and C_7. The maximum output voltage from the filter is supplied to the output audio stage. The primary of the power transformer is tapped to permit the operation of the receiver on line voltage from 100 to 130 volts.



CIRCUIT OF THE RECEIVER AND POWER SUPPLY

No. 10. October, 1928.

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

The Splitdorf "Inherently Electric" Receiver

THIS sheet is devoted to a discussion of a six-tube, completely self-contained electric receiver. It employs a.c. tubes, is single controlled and consists of three stages of r.f., a detector and two stages of transformer-coupled audio amplification. It is designed for operation from a 110-volt, 60-cycle light socket. Type 226 tubes are used in the r.f. amplifier and in the first a.f. stage. The detector is a type 227 tube and the output tube is a type 171A. The antenna circuit is arranged with several taps to adapt the operation of the set to short, medium and long antennas.

A NEW SPLITDORF MODEL

This beautifully housed receiver is the new Splitdorf Abbey Senior. It incorporates many new features not found in the older Splitdorf circuit described in this Sheet. It uses six tubes, one of them a 250 type, and is equipped with a phonograph jack and a novel "sensitivity-selectivity" switch.

TECHNICAL DISCUSSION

1. Tuning System.

The tuning system comprises four r.f. transformers and tuning condensers consisting of L_1 and C_1, L_3 and C_1, L_5 and C_1, and L_7 and C_1. A single-gang assembly contains all four tuning condensers, each section of which has a capacity of 0.00035 mfds. The antenna is connected to A_1, A_2, or A_3, depending upon whether it is short, or medium length, or long. The small variable inductor forming part of L_1 is in the circuit so that the effect of the antenna on the first tuned circuit may be compensated and this circuit brought into exact resonance at all wavelengths.

This receiver is not neutralized but is stabilized by grid resistors, R_1, R_2, and R_3, each with a value of 600 ohms. This method of oscillation control is used in many receivers and is quite effective.

2. Detector and Audio System

The grid-leak-condenser type detector employed in this receiver uses a 0.00025-mfd. grid condenser, C_3, in conjunction with a 2-megohm grid leak, R_5. The detector is a type 227 tube and its output is fed into a two-stage transformer-coupled audio amplifier. The output of the detector circuit is bypassed by C_4 with a capacity of 0.0001 mfd. The first stage audio transformer, T_1, has connected across its secondary a small fixed condenser, C_5, of 0.00025 mfd., probably to prevent singing in the a.f. amplifier at high frequencies. The output of T_1 supplies signal voltage to the grid of V_5, a 226 type a.c. tube. The loud speaker is isolated from the plate circuit of the power tube by a choke-condenser combination consisting of choke coil X_2 and condenser C_{11}; this condenser has a capacity of 1.0 mfd.

3. Volume Control.

A 500,000-ohm variable resistance, R_4, is connected across the input to the detector in this receiver and functions as the volume control. The input circuit of a grid leak and condenser type detector is generally quite low and as a result the tuned circuit preceding it has poor selectivity. It is therefore a good idea to place the volume control at this point, for at this point in the circuit it cannot affect the selectivity of the receiver to any marked degree. Since the control is ahead of the detector it is possible to regulate the volume to prevent overloading of the detector tube.

4. Filament Circuits.

Filament current for the various tubes in the receiver is supplied by the power transformer, T_3. Secondary winding S_1 supplies 1.5 volts to the 226 type tubes, secondary S_2 supplies 2.5 volts for the heater of the detector tube and secondary S_3 supplies 5.0 volts for the power tube. S_3 also supplies current for the dial light. All the filament circuit leads are twisted to prevent hum, and 30-ohm potentiometers, R_6 and R_7, are connected across the secondaries, S_1 and S_2, to make it possible to obtain a very accurate hum balance.

5. Plate Circuits.

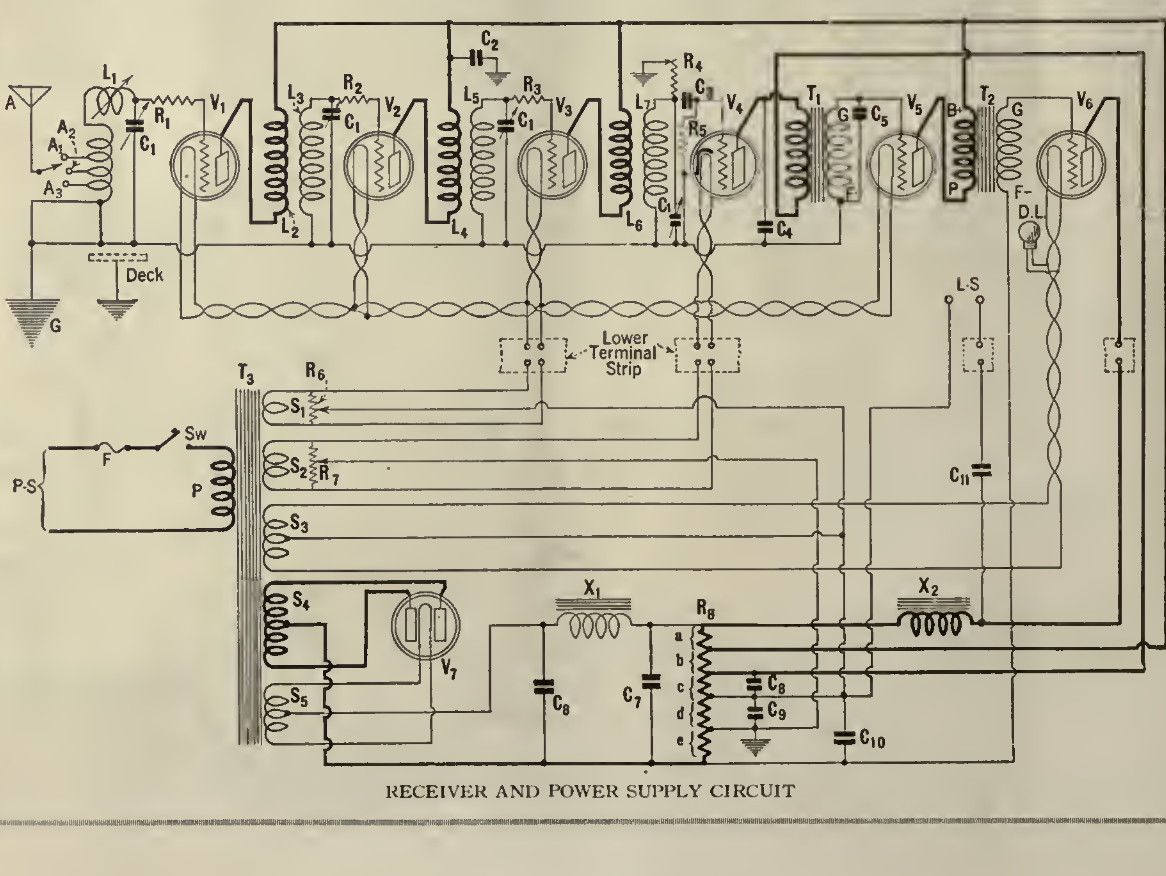
The output tube, V_6, of the audio amplifier is supplied with the maximum voltage from the power supply unit—180 volts. All the r.f. tubes and the first a.f. tube receive 110 volts and the detector is supplied with 45 volts. The plate circuits of the r.f. tubes are bypassed in the set with condenser C_2, whose capacity is 0.5 mfd. The detector plate supply bypass condenser is C_8, located in the power unit. Its value is 1.0 mfd.

6. Grid Circuits.

The output tube of the set has a bias on the grid of 40 volts, supplied by sections of the resistor, R_8, in the power unit. The bypass across this resistor, C_{10}, has a value of 1.0 mfd. Section *d* of the resistor supplies bias for the first a.f. and all the r.f. tubes. This bias voltage is 7.5 volts and the bias resistor is bypassed by the 2.0-mfd. condenser, C_9. The tone quality would be very poor, due to loss of the low frequencies, if these bypass condensers, C_9 and C_{10}, were not included in the circuit across the C bias resistances.

7. The Power Supply.

The A-B-C supply for this receiver consists of the power transformer, T_3, the rectifier, V_7, which is a type 280 tube, the filter system and the voltage dividing resistor, R_8. This resistor has a total value of 13,200 ohms divided as follows: section *a*, 2500 ohms; section *b*, 5400 ohms; section *c*, 4500 ohms; section *d*, 150 ohms; section *e*, 650 ohms. The filter circuit consists of the filter choke coil, X_1, and the two filter condensers, C_6, with a value of 4.0 mfd., and C_7 with a value of 6.0 mfd. The primary of the transformer is fused at F and the entire receiver is turned on and off by the switch, Sw.



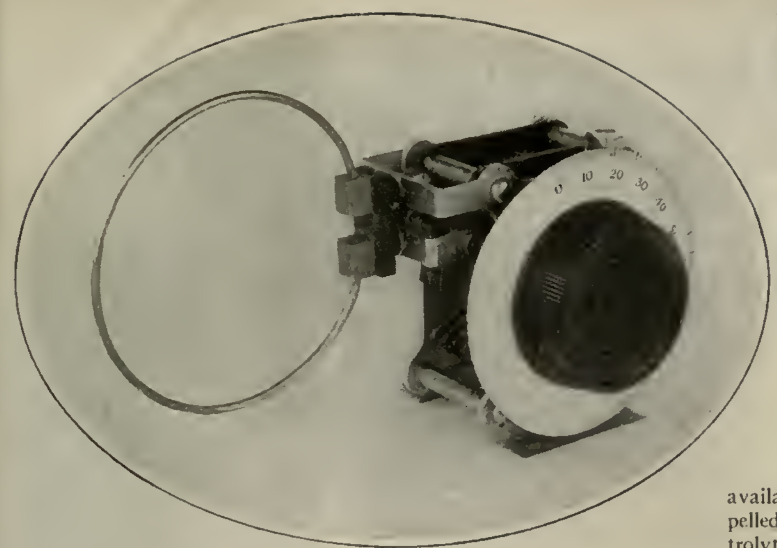
RECEIVER AND POWER SUPPLY CIRCUIT

Practical 5-Meter Hints

By ROBERT S. KRUSE

THIS short article contains some operating data which Mr. Kruse did not cover in his article on 5-meter transmission and reception in the September issue of RADIO BROADCAST. *Several "freak" transmission effects on the 5-meter band are also explained.*

—THE EDITOR.



THE 5-METER WAVEMETER

IN THE preceding stories the very attractive possibilities of the 5-meter band have been discussed. There will be added here a few time-saving hints.

Very early it became evident that the average experimenter did not make a satisfactory job of building and calibrating a 5-meter wavemeter. At the writer's suggestion the General Radio Co. developed the very rugged little meter shown on this page, which remains the only one on the market, although the band-covering

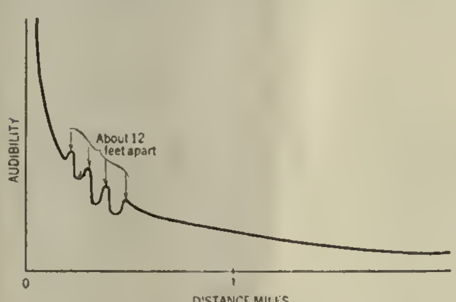


FIG. 1. "WEST PEAKS"

meter of the same firm also has a 5-meter coil. The meter here shown is most convenient when mounted on a short wooden or bakelite panel, although the hand-capacity effects are small because of a good C/L proportion.

In the previous articles the plate and filament supply were not mentioned. It is best to use alternating filament supply, but one should *not* use the center-tap of a transformer secondary. It is far more satisfactory to use a double 100-ohm resistor or a 200-ohm potentiometer. The latter has the advantage of permitting one to find exactly the right point. Either method permits one to use any toy transformer or even a bell-ringing transformer.

The plate supply may be raw a.c. as a starter, as was suggested, but had better be rectified. The filter should *not* have a condenser next to the rectifier tube. First should come a choke of 1–5 henrys inductance, then a 2.0-mfd. condenser, then a choke of 10–100 henrys and finally another condenser, as large as convenient, shunted by a resistance of 25,000-100,000 ohms. The reasons for this type of filter are good but too lengthy to mention here.

Although the UX-852 tube is excellent for the 5-meter band, no proper rectifier for it is available. One is compelled to use electrolytic rectification, or else a too-large kenotron, mercury arc or d.c. generator. A new gas tube may be available soon.

When the set is taken into the field one must of course have some sort of automatic key at the station to keep making signals. A suitable one is shown herewith. It consists of the motor of a 16″ electric fan, a standard Boston Gear Works worm gear and a cam in the edge of which are milled code letters as desired. A bakelite cam worked out with a file is just as good. The edge of the cam bears on a brass strip screwed under the knob of an ordinary telegraph key which controls the transmitter. Parenthetically, it is best to key the set by the method shown in Fig. 2—for reasons good but lengthy.

Having the key going one gets into the field with the receiver and is then uncertain whether things are proceeding well. The appearance of the following effects is normal and reassuring.

AUTOMOTIVE EFFECTS

BEFORE one is long afield the automobile injects itself into the picture. Its ignition noises are rather troublesome, although this is lessening as the Model T Fords and their spark coils diminish in number. After a little practice one can distinguish the type of motor and its condition to a considerable degree by listening with a 5-meter receiver as a car passes. Cars with monthly service programs have vastly the best average performance as re ards the steadiness of their 5-meter signals.

THE AUTOMATIC KEY

If one is near the road another effect will be observed: each passing car detunes the received signal a trifle. This statement is made general, though we must admit lack of evidence against the Rolls Royce, which did not come along that road. It was possible to tune the station out, and then bring it back by interposing a suitable automobile. "Suitable" means any type of about the right size and body structure; a Buick and a Nash are interchangeable for the purpose, whereas a Franklin and a Stutz are not! The gist of the difference lies in the difference between the wood-and-aluminum body of the "Benjamin" as compared with the fabric-covered

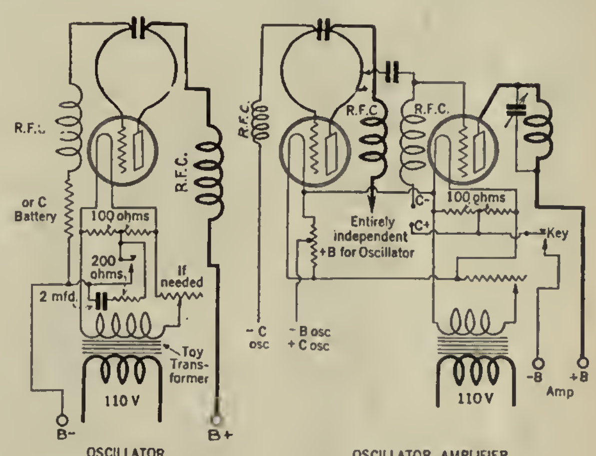


FIG. 2. THE KEYING DIAGRAM

Stutz body, and the only possible value of the stunt is to suggest the importance of small absorption effects at 5 meters.

"WEST'S PEAKS"

TO C. H. West of 2CSM we are indebted for first calling attention to the curious effect shown in Figure 1. He noticed that in driving along a road there appeared to be "humps" in the signals at 12-foot intervals when one was some $\frac{1}{2}$ or $\frac{3}{4}$ mile from the station. Subsequent observations produced the same effect at various stations, the spacing between peaks remaining reasonably constant, though sometimes the peaks are entirely absent at a particular station. The same thing has since been observed at $\frac{3}{4}$-meter wavelength with all the dimensions of the picture about one seventh as large. It looks like an interference pattern, but in most cases appears to be stationary and of much the same proportions regardless of the things alongside the road at that place.

New Apparatus

PRODUCTS of radio manufacturers whether new or old are always interesting to our readers. These pages, a feature of RADIO BROADCAST, *explain and illustrate products which have been selected for publication because of their special interest to our readers. This information is prepared by the Technical Staff and is in a form which we believe will be most useful. We have, wherever possible, suggested special uses for the device mentioned. It is of course not possible to include all the information about each device which is available. Each description bears a serial number and if you desire additional information direct from the manufactuter concerned, please address a letter to the Service Department,* RADIO BROADCAST, *Garden City, New York, referring to the serial numbers of the devices which interest you, and we shall see that your request is promptly handled.*—THE EDITOR.

Shielded Wire Prevents Stray Coupling

X60

Device: SHIELDED HOOK-UP WIRE. This hook-up wire is a rubber-covered No. 18 with an additional braid of metal over the rubber insulation. When this metal braid is grounded it forms an effective shield around the wire. The metal braid is sufficiently flexible so that the wire may be readily bent into any desired form. It has all the conveniences of a flexible hook-up wire with the additional advantage that it is shielded. It is available in rolls of 100 feet. *Manufacturer:* Belden Manufacturing Company. *Price:* $3.50 per 100' roll.

Application: In constructing high gain r.f. amplifiers, especially those using type 222 screen-grid tubes, it is absolutely essential that no coupling of any sort exist between the input and output circuits of the tube. Frequently it is possible that the comparatively short leads connecting one tube to the next will produce sufficient capacitative coupling to some other part of the circuit to cause the amplifier to oscillate. Coupling of this type can be eliminated by the use of shielded wire. The circuit diagram in Fig. 2 indicates at what point in the circuit of a stage of r. f. amplification it might be wise to use shielded conductor.

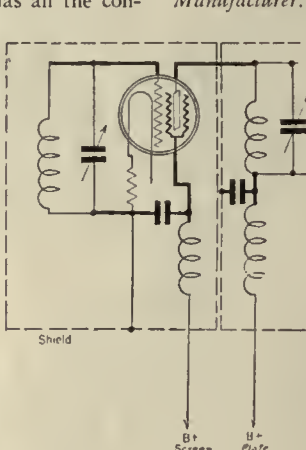


FIG. 2

For Smoother Volume Control

X61

Device: VARIABLE HIGH RESISTANCES. For volume control. Many of us when operating a volume control have noticed that frequently the volume does not vary uniformly as the control is turned. Turning the control a given distance at a certain point will produce a given change in volume and then turning it twice as far will produce a very much greater change in volume. It would be desirable to make use of a volume control resistor of a characteristic such that the changes in volume were more nearly proportional to the movements of the control.

Resistances of this type have been designed to give uniform variation of volume and can be

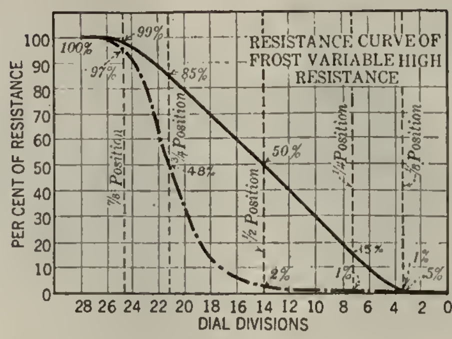


FIG. 1

obtained in sizes ranging from 2000 to 10,000 ohms. The curves of such resistances are given in Fig. 1. The solid curve indicates that of an ordinary resistance in which the variation in the resistance is directly proportional to the dial setting. The dot-dash curve is that of the new type resistance. It will be seen that the resistance does not vary directly with the dial setting but varies slowly at first and then more rapidly, which results in smoother volume control.

The catalog numbers and prices of these new type resistances are given below.

No. 1896, 2000 ohms—$2.25
No. 1897, 5000 ohms— 2.25
No. 1898, 10,000 ohms— 2.25

Manufacturer: Herbert H. Frost, Inc.

Application: As indicated above these units are designed for use as volume controls in radio receivers, and because of their special characteristics have certain advantages over other types of resistances. All of these resistors are made with three terminals, like a potentiometer, and can be used as a potentiometer type of control or, if desired, by connecting to the center terminal and one of the outside terminals, the unit can be used as a two terminal resistor. The direction of rotation of the knob to decrease or increase the resistance will depend upon which outside terminal is connected.

A Safeguard for A. C. Tubes

X62

Device: CENTRALAB RADIO CONTROL BOX. This is a device designed for use in conjunction with light-socket operated receivers. It consists of a small metal box in which is placed a variable resistance. The power lead on the box is plugged into the light socket and then the power lead from the receiver is plugged into the receptacle on the box. This places the variable resistance in

CENTRALAB CONTROL BOX

series with the line. If the line voltage is excessive, i. e., greater than that on which the set is designed to operate, the control on the box can be adjusted so that part or all of the resistance is in series with the line and the excess voltage will then be absorbed.

Manufacturer: Central Radio Laboratories. *Price:* $3.00.

Application: Excessive line voltages have evidently caused considerable trouble with a.c operated receivers. If a.c. tubes, or any tubes for that matter, are subjected to excessive filament voltage, their life is materially shortened. Excessive line voltage supplies excessive filament voltages to tubes in a set, and it is essential, therefore, that some device be used to permit compensation for line voltages greater than about 110, the voltage on which most receivers are designed to operate. A device of this sort, of course, requires manual control if the line voltage varies during the day and night. Also there is no means of determining when the voltage applied to the set is 110. Probably the best method of operation, therefore, is to gradually increase the resistance (which reduces the voltage applied to the receiver) until an effect on reception is noted and then to decrease slightly the resistance.

Devices can be obtained which will automatically regulate the line voltage so that the receiver is always supplied with exactly 110 volts. Such devices are expensive, costing perhaps five times as much as this device. For a simple unit that will permit longer life from a.c. tubes the power control box is to be recommended.

A Complete Push-Pull Amplifier

X63

Device: PUSH-PULL AMPLIFIER, MODEL P-P-2. A complete single-stage push-pull amplifier designed for the use of two 171 type tubes. This device does not contain any power supply, but must be operated in conjunction with batteries or A and B power units. *Manufactured* by HAROLD POWER, INC. *Price:* $38.00, with tubes.

Application: This amplifier is designed for use in conjunction with a radio receiver in those cases where more power output is desired than can be obtained without distortion from the power tube incorporated in the receiver. This amplifier can deliver at least 1400 milliwatts of power without overloading—about ten times as much as can be obtained, for example, from a 112A type tube.

A Plug Which Can't Be Broken

X64

Device: SOFT RUBBER PLUG. Ruggedly constructed of solid soft rubber. Shaped to form a convenient grip for the fingers when pushing it in or pulling it out of a socket. Only sold attached to Belden cords which come in 10-, 20-, and 50-foot lengths. *Manufactured* by the BELDEN MANUFACTURING COMPANY. *Price:* $2.75.

Application: This plug can be thrown around, dropped, or stepped on without fear of breaking it. Judging from the number of ordinary hard rubber plugs that have been broken in RADIO BROADCAST Laboratory we venture a guess that we ought to have about 600 of these!

A 30-Henry Choke for Filter Circuits

X65

Device: SAMSON FILTER CHOKE COIL, TYPE 312. A choke coil designed for use in the filter circuits

of B-power units. It is capable of carrying direct currents up to and somewhat in excess of 120 milliamperes. At 120 mA. its inductance is 30 henrys. The d.c. resistance of the choke is approximately 290 ohms. *Manufacturer:* Samson Electric Manufacturing Company. *Price:* $12.00. *Application:* The choke coil is applicable to various filter circuits in which it is necessary that the circuit handle currents of about 120 mA. If the value of current does not reach values higher than about 80 mA. then the Samson choke type 380 ($11.00) may be used; for currents not in excess of 30 mA. the type 30 ($5.00) is satisfactory.

SAMSON CHOKE

The low-resistance characteristic of these choke coils makes them very satisfactory for use in filter systems, for with low-resistance circuits the voltage regulation of the power unit will be better than with high-resistance circuits; the resistance of the filter choke coils should be low enough so as not to have any great effect on the regulation of the system. These requirements are fulfilled very satisfactorily hy Samson chokes.

Radio-Frequency Choke Coils

X66

Device: RADIO-FREQUENCY CHOKE COILS. Two types are available.

Code No. RFC-85, with an inductance of 85 millihenrys, a distributed capacity of 3 mmfds. and a resistance of 215 ohms. *Price:* $2.00.

Code No. RFC-250, with an inductance of 250 millihenrys, a distributed capacity of 2 mmfds. and a resistance of 420 ohms. *Price:* $2.25

Manufacturer: HAMMARLUND MANUFACTURING COMPANY.

Application: These r.f. chokes are for use in the r.f. B-plus leads and in the detector plate lead to keep the r.f. currents out of the plate supply unit and out of the audio amplifier. Although two types are available it is likely that in broadcast receivers the cheaper 85-millihenry choke may be satisfactorily used in all cases. The impedance of these coils at broadcast frequencies will be determined by the distributed capacity of the coil. At 1500 kc. the impedance of the 85-millihenry coil will be about 30,000 ohms and the impedance of the 250 millihenry coil about 45,000 ohms. The 85-millihenry coil, however, will give at broadcast frequencies a sufficiently high impedance so that satisfactory filtering action can be obtained. It is interesting that the coil with the higher inductance has less distributed capacity than the smaller coil.

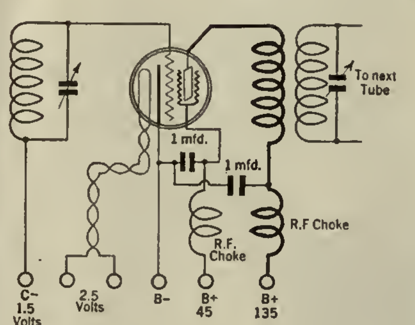


FIG. 3

THE A. C. 22 TUBE

R. f. choke coils of this type can also be used in constructing an intermediate-frequency amplifier for a super-heterodyne. An example of such a use can be seen by referring to the article by L. T. Goldsmith in the May, 1928, issue describing the construction of a super-heterodyne.

A Neon Lamp for Television

X67

Device: KINO LAMP. A neon tube designed for use in television receiving apparatus. The tube measures about $6\frac{1}{2}''$ high and about 2″ in diameter and is fitted with a UX type base so that it can be plugged into a standard tube socket. The a.c. resistance of the tube is about 1200 ohms and the current through the tube should not exceed about 20 milliamperes d.c. This corresponds roughly to about 200 volts across the tube. The three circuit diagrams in Fig. 4 show circuits in which the tube may be used in television receivers. All three circuits are quite satisfactory, circuit A probahly being the simplest in construction and operation.

Manufacturer: Raytheon Manufacturing Company. *Price:* $12.50.

Application: The principal use for this tube is in the output circuits of television receivers, although it may be used in any place where a gas discharge tube is required, and probably other applications for it will suggest themselves to our readers. Since the plate of the tube is about $1\frac{1}{2}''$ square the received television picture will be of the same size. A word of caution—never overload the tube. Don't put it across a d.c. source of voltage without a current limiting resistance in series with it. Keep the current as low as possible, for the lower the current used, the longer the life of the tube will be.

An A.C. Screen-Grid Tube

X68

Device: A. C. SCREEN-GRID TUBE, TYPE A. C. 22. The tube is of the same general construction as d.c. screen-grid tubes with the exception that the electron emitting member has a heater similar to that used in type 227 tubes. The heater requires 2.5 volts to operate it. This tube may therefore be connected in parallel with 227 type tubes, since they also require 2.5 volts. The a.c. 22 tube fits into a standard 5-prong socket. *Manufacturer:* CeCo Manufacturing Company. *Price*, $8.00.

Application: This tube is for use in the construction of a.c. operated receivers requiring the use of a screen-grid tube. The connections of a single r.f. stage using this tube are given in Fig. 3.

Filter and Bypass Condensers

X69

Device: ACME PARVOLT CONDENSERS. These condensers are available in all standard capacities and voltage ratings. Both bypass condensers designed for comparatively low voltage and filter condensers designed for 200, 400, 600, 800, 1000, and 1500 volts can be obtained. The condensers are tested and fully meet the standards of the R. M. A. Complete block condensers can also be obtained designed for use in the various types of well-known power units, such as the Samson, Amertran, Silver-Marshall, Thordarson, etc.

ACME CONDENSERS

Manufacturer: Acme Wire Company. *Prices:* Vary depending upon capacity and voltage rating of the condensers.

Application: These condensers are designed to fulfill every need for condensers in radio receivers and power units. The condensers are equipped with mounting feet and screw terminals.

FOR TELEVISION

Loud Speaker Extension Cords

X70

Device: LOUD SPEAKER EXTENSION CORD. A 50-foot extension cord equipped with pin terminals on each end. Supplied with a bakelite connector for easy connection between the extension cord and the loud speaker. The cord consists of two rubber insulated wires covered with a brown cotton braid. *Manufacturer:* BELDEN MANUFACTURING COMPANY. *Price:* $2.25

Application: This extension cord will prove useful in cases where the loud speaker is to be operated at a point distant from the radio receiver. In the good old summer time the loud speaker might be placed outside on the lawn, under a shady chestnut tree. To control the volume, use can be made of a variable resistor such as a Table Type Clarostat (mentioned in this department in the May issue) connected across the loud speaker terminals.

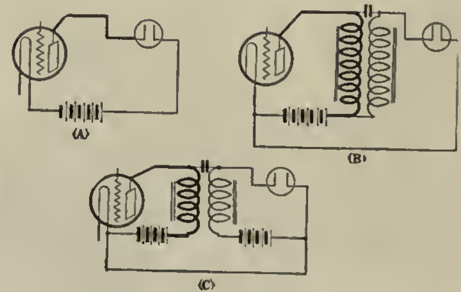


FIG. 4

THE U. S. COAST AND GEODETIC SURVEY SHIP *SURVEYOR*

Radio Helps in the Coast Survey

By D. L. PARKHURST

Chief, Instrument Division, U. S. Coast and Geodetic Survey

THE method of acoustic range finding described by Mr. Parkhurst seems to have several advantages over the radio beacon system, when used for short distances over uniform masses of fairly deep water. The actual distance of the ship from shore stations is measured by the time taken for sound waves to pass through the water from ship to shore, whereas in the beacon system only the bearings of shore stations may be determined. Furthermore, the acoustic system is entirely automatic, the time of the signals being mechanically recorded on the chronograph tape aboard the ship. With the beacon system there is always a possible error due to the operator. On the other hand, the acoustic method has proved itself useful only over short distances (200 miles at the most), and through water that is uniform in temperature and not broken up by shoals. These advantages indicate that it might have great usefulness as a guide to ships at the entrances of harbors.

—THE EDITOR.

THE use of radio for direction and range finding has made great strides in the past few years, especially in the development of directive beacons for sea and air navigation. The U. S. Coast and Geodetic Survey has recently developed another interesting method of range finding, which makes use of both sound and radio waves. In making depth measurements off the coast it is frequently necessary for the Survey ships to be out of sight of land, so that ordinary triangulation methods of accurately locating the position of the ship cannot be used. In such cases the position of the ship is determined by a method known as acoustic range finding, in which the distance of the ship from shore is measured by the velocity of sound waves through water, the recording being effected by means of radio.

When the surveying ship has made a depth measurement, or sounding, a bomb containing a pound or so of high explosive, such as TNT, is dropped overboard and exploded twenty or more feet beneath the surface. The sound produced is picked up by a submerged microphone, or hydrophone, located on the ship, and the impulse transmitted through a three-stage audio amplifier to the pen-actuating magnet of a chronograph, making a mark on a paper recording strip. The sound of the explosion also travels through the water in all directions, and is picked up by hydrophones anchored in approximately fifty feet of water at two or three known points on the shore. Insulated cable connects these hydrophones to a three-stage amplifier at each shore station. The amplified signal actuates a relay which sends a flash from a simple 140-meter low-power radio transmitter. The radio signal is picked up by a tuned receiver on board the ship, and amplified, and this current also actuates the chronograph pen beforementioned.

FIG. 1. ONE OF THE AUTOMATIC TRANSMITTING KEYS

The paper strip, or tape, has been moving at a uniform rate during the time between the bomb explosion and the reception of the radio flash, and consequently the space between the two pen marks is an index of the elapsed time.

Accurate measurements have determined that the velocity of sound through sea water is approximately 4920 feet per second, varying somewhat with the water temperature. For example, if the elapsed time is 60 seconds, the ship is consequently 295,200 feet, or 55 10/11 miles, from the shore station.

The information is not complete if only one shore station is in operation, as the ship may be anywhere on a circle whose radius equals the time multiplied by the velocity of sound in water; consequently, two or more stations are used and the crossing point of the arcs for each station in-

dicates the ship's position. Fig. 3 illustrates this graphically. An automatic signaling device is attached to the transmitter of each shore station so that it sends out a characteristic signal and may be readily identified.

HOW THE SYSTEM OPERATES

IN GREATER detail, the operation of the apparatus is as follows: The bomb, a tin can or cast-iron container, is filled with loose TNT, and just before firing a No. 8 blasting cap, with a length of Bickford powder train blasting fuse crimped to it, is inserted, the joint being sealed with wax or other plastic. The fuse is anchored so that the cap will not pull out.

At the proper moment, after a sounding has been completed, the fuse is lighted and the bomb thrown overboard. When the explosion occurs, the sound excites the carbon grain button in the ship's hydrophone, which is located in a small tank of water attached to the outer skin of the vessel. The ensuing current is amplified in a three-stage audio amplifier using two 201A and one 171 tubes and 6 to 1 transformers. The amplified current passes through the coils of a pen-operating magnet on a chronograph. The chronograph, shown in Fig. 2, is of a commercial type, having two pens, and is driven by a 6-volt, storage battery shunt motor.

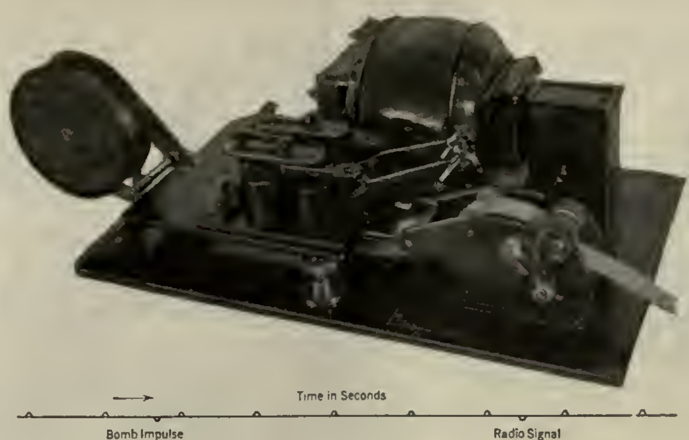


FIG. 2. THE RECORDING CHRONOGRAPH

Two pens can be seen poised above the tape in the chronograph. The relay operating one of the pens is actuated by the chronometer; the other relay is operated by the signals from the hydrophone and the short-wave receiver on the ship. The type of record made is indicated below the photograph.

Such a motor will run at practically constant speed, as the load is very light. In fact it is only necessary that the speed be constant during the first and last seconds.

The timing device consists of a high grade marine chronometer fitted with a circuit breaking device which operates each second, causing the second chronograph pen to make a mark on the record strip, which is standard ¾-inch stock ticker tape. Fig. 2 shows at the bottom the type of record made on this tape.

After the record of the explosion has been made by means of the ship's hydrophone, the tape continues to pass through the chronograph, each second being marked upon it by the chronometer. The sound from the bomb travels through the water to the hydrophones of the shore station. These are sometimes anchored as much as two miles offshore, depending upon the character of the sea bottom, as it has been found that the system does not operate so well unless the hydrophones are at least 50 feet below the surface. Submarine cable, armored where wave action may cause chafing, connects the hydrophones to the shore station apparatus.

The energy from the hydrophones is amplified in a three-stage amplifier, which is very similar to that used aboard ship, and the current actuates an 800-ohm relay which completes a circuit through a 140-meter transmitter, sending out a radio flash. At the same time this relay sets an automatic telegraph key in operation which sends out three additional, equally timed flashes from the transmitter. No two keys have the same timing, so that each station may be identified by its characteristic markings on the chronograph tape. The automatic keys, one of which shown in Fig. 1, are made up with an ordinary musician's metronome as a time element, having the spring removed and weight drive substituted for it. A standard pony relay is mounted directly beneath it with a finger attached to its armature which engages with a similar finger on the pendulum of the metronome when it is in the off position. The impulse from the bomb pulls the armature over, releasing the metronome mechanism, and a suitable system of contacts acting on a notched wheel attached to the time shaft opens and closes circuits in such a manner that the armature is held over during one complete revolution of the time shaft and at the same time sends out three flashes through the radio transmitter. When one revolution has been made the armature is released and the metronome stops.

The transmitter is a single UX-210 tube instrument designed to transmit at 140 meters. It is sufficiently powerful to transmit through approximately two hundred miles.

The initial and the three identifying flashes from the shore transmitter are picked up on the ship by a standard make of short-wave radio receiver. This receiver contains a detector tube and two stages of audio amplification, and additional amplification is secured by connecting this receiver to the three-stage amplifier previously described. The panel of this amplifier is fitted with a double throw switch, by means of which either the hydrophone or the radio receiver may be connected to it. As soon as the explosion has occurred and has been recorded, this switch is thrown over, disconnecting the hydrophone and connecting the radio receiver ready for the impulse from the shore station to be recorded. The amplified radio signal actuates the second chronograph pen previously referred to, making a mark upon the tape.

RESULTS

THE tape now contains a line punctuated at one side with the one second marks recorded by the chronometer. The other side of this line is punctuated with the impulse from the hydrophone and also those from the several shore stations with their characteristic identification marks. The time elapsed between the bomb explosion and the radio reception may be readily determined by counting the number of second marks and by measuring the fractions at each end. Multiplying this figure by the velocity of sound through sea water gives the distances from the ship to the several shore stations. As the geographic positions of these stations are already known, arcs of the proper radii are struck from each and their intersections indicate the ship's position. Amply accurate results for the type of work have been obtained by this means.

This system possesses certain difficulties of operation in some localities. Experience has shown that the apparatus works better where the bottom falls rapidly away from the shore and where the water is cold and of fairly even temperature. Shoals also seem to present difficulties in the transmission of sound through water. The exact influence of each of these factors has not been fully determined, but active investigation is being carried on. On the Atlantic Coast of the United States, where the continental shelf extends for a good many miles offshore, and also where the water is comparatively warm, considerable difficulty has been experienced in getting the apparatus to work satisfactorily over any great distance. On the other hand, on the West coast, where these conditions do not obtain, excellent results have been achieved over a distance of about two hundred miles.

The system has such attractive possibilities for the location of positions at sea rapidly and economically, that development work will be rapidly carried on in an effort to perfect its use under all conditions.

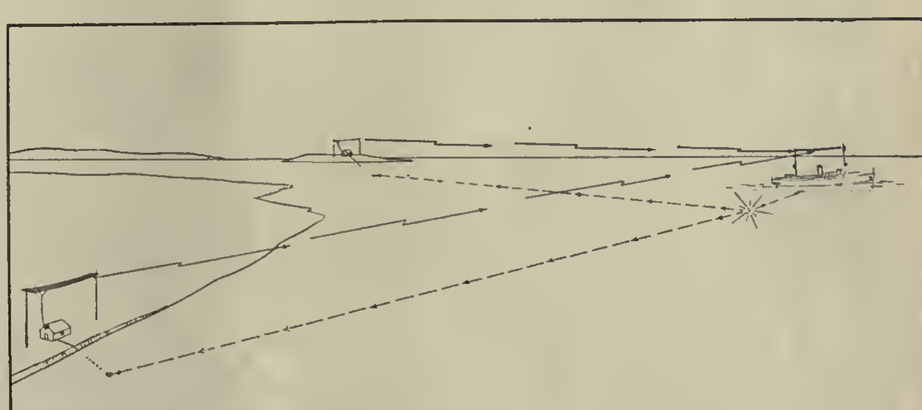


FIG. 3. THE ACOUSTIC RANGE FINDING METHOD

The bomb exploded under water by the ship produces sound waves that are picked up by the hydrophones of the two shore stations, causing the two shore stations to transmit radio signals. These are picked up by the ship, and the elapsed time between explosion and signals gives the data for the calculation of the distance of the ship from the two shore stations. Thus its position can be located.

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on this page. Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. 1928 revised booklet, with circuit diagrams of popular kits. RADIALL COMPANY.

5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.

9. VOLUME CONTROL—A leaflet showing circuits for distortionless control of volume. CENTRAL RADIO LABORATORIES.

10. VARIABLE RESISTANCE—As used in various circuits. CENTRAL RADIO LABORATORIES.

12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.

15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.

15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.

17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.

23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.

26. DRY CELLS FOR TRANSMITTERS—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. BURGESS BATTERY COMPANY.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

32. METERS FOR RADIO—A catalogue of meters used in radio, with diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

36. CHARGING A AND B BATTERIES—Various ways of connecting up batteries for charging purposes. WESTINGHOUSE UNION BATTERY COMPANY.

37. WHY RADIO IS BETTER WITH BATTERY POWER—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.

46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.

47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.

48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.

53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.

56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.

57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.

58. HOW TO SELECT A RECEIVER—A common-sense booklet describing what a radio set is, and what you should expect from it, in language that anyone can understand. DAY-FAN ELECTRIC COMPANY.

67. WEATHER FOR RADIO—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. TAYLOR INSTRUMENT COMPANIES.

69. VACUUM TUBES—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. RADIO CORPORATION OF AMERICA.

70. IMPROVING THE AUDIO AMPLIFIER—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. AMERICAN TRANSFORMER COMPANY.

72. PLATE SUPPLY SYSTEM—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. AMERTRAN SALES COMPANY.

73. RADIO SIMPLIFIED—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. CROSLEY RADIO CORPORATION.

76. RADIO INSTRUMENTS—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. JEWELL ELECTRICAL INSTRUMENT COMPANY.

78. ELECTRICAL TROUBLES—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. BURTON ROGERS COMPANY.

81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.

84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.

85. FILTER—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. THE ABOX COMPANY.

87. TUBE TESTER—A complete description of how to build and how to operate a tube tester. BURTON-ROGERS COMPANY.

88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.

89. SHORT-WAVE TRANSMITTER—Data and blue prints are given on the construction of a short-wave transmitter, together with operating instructions, methods of keying, and other pertinent data. RADIO ENGINEERING LABORATORIES.

90. IMPEDANCE AMPLIFICATION—The theory and practice of a special type of dual-impedance audio amplification are given. ALDEN MANUFACTURING COMPANY.

92. RESISTORS FOR A. C. OPERATED RECEIVERS—A booklet giving circuit suggestions for building a.c. operated receivers, together with a diagram of the circuit used with the new 400-milliampere rectifier tube. CARTER RADIO COMPANY.

95. Resistance Data—Successive bulletins regarding the use of resistors in various parts of the radio circuit. INTERNATIONAL RESISTANCE COMPANY.

96. VACUUM TUBE TESTING—A booklet giving pertinent data on how to test vacuum tubes with special reference to a tube testing unit. JEWELL ELECTRICAL INSTRUMENT COMPANY.

In sending the coupon below, make sure that your name and address are included and are plainly written. Also make sure that the listing of booklets from which you choose is that of the latest issue of the magazine, as Radio Broadcast cannot guarantee the delivery of booklets not listed in its current issue.

USE THIS BOOKLET COUPON

RADIO BROADCAST SERVICE DEPARTMENT
RADIO BROADCAST, *Garden City, N. Y.*

Please send me (at no expense) the following booklets indicated by numbers in the published list above:

. . . .

. . . .

Name. . . . .
(Number) *(Street)*

Address. . . . .
(City) *(State)*

. . . .

ORDER BY NUMBER ONLY

This coupon must accompany every request. R B 9-28

98. COPPER SHIELDING—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. THE COPPER AND BRASS RESEARCH ASSOCIATION.

99. RADIO CONVENIENCE OUTLETS—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set. YAXLEY MANUFACTURING COMPANY.

101. USING CHOKES—A folder with circuit diagrams of the more popular circuits showing where choke coils may he placed to produce better results. SAMSON ELECTRIC COMPANY.

102. RADIO POWER BULLETINS—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the BH or B rectifier tubes. RAYTHEON MANUFACTURING COMPANY.

104. OSCILLATION CONTROL WITH THE "PHASATROL"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. ELECTRAD, INCORPORATED.

105. COILS—Excellent data on a radio-frequency coil with constructional information on six broadcast receivers, two short-wave receivers, and several transmitting circuits. AERO PRODUCTS COMPANY.

108. VACUUM TUBES—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. ARCTURUS RADIO COMPANY.

110. RECEIVER CONSTRUCTION—Circuit diagram and constructional information for building a five-tube set using restricted field coils. BODINE ELECTRIC COMPANY.

111. STORAGE BATTERY CARE—Booklet describing the care and operation of the storage battery in the home. MARKO STORAGE BATTERY COMPANY.

112. HEAVY-DUTY RESISTORS—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. WARD LEONARD ELECTRIC COMPANY.

113. CONE LOUD SPEAKERS—Technical and practical information on electro-dynamic and permanent magnet type cone loud speakers. THE MAGNAVOX COMPANY.

114. TUBE ADAPTERS—Concise information concerning simplified methods of including various power tubes in existing receivers. ALDEN MANUFACTURING COMPANY.

115. WHAT SET SHALL I BUILD?—Descriptive matter, with illustrations, of fourteen popular receivers for the home constructor. HERBERT H. FROST, INCORPORATED.

116. USING A B POWER UNIT—A comprehensive booklet detailing the use of a B power unit. Tables of voltages—both B and C—are shown. There is a chapter on trouble-shooting. MODERN ELECTRIC MFG. CO.

118. RADIO INSTRUMENTS. CIRCULAR "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. WESTON ELECTRICAL INSTRUMENT CORPORATION.

120. THE RESEARCH WORKER—A monthly bulletin of interest to the home constructor. A typical feature article describes the construction of a special audio amplifier—AEROVOX WIRELESS CORPORATION.

121. FILTER CONDENSERS—Some practical points on the manufacture and use of filter condensers. The difference between inductive and non-inductive condensers. POLYMET MFG. CORP.

123. B SUPPLY DEVICES—Circuit diagrams, characteristics, and list of parts for nationally known power supply units. ELECTRAD, INC.

124. POWER AMPLIFIER AND B SUPPLY—A booklet giving several circuit arrangements and constructional information and a combined B supply and push-pull audio amplifier, the latter using 210 type tubes. THORDARSON ELECTRIC MFG. CO.

125. A. C. TUBE OPERATION—A small but complete booklet describing a method of filament supply for a.c. tubes THORDARSON ELECTRIC MFG. CO.

126. MICROMETRIC RESISTANCE—How to use resistances for: Sensitivity control; oscillation control; volume control; regeneration control; tone control; detector plate voltage control; resistance and impedance coupling: loud speaker control, etc. CLAROSTAT MFG. CO.

129. TONE—Some model audio hook-ups, with an explanation of the proper use of transformers and chokes. SANGAMO ELECTRIC CO.

130. SCREEN-GRID AUDIO AMPLIFICATION—Diagrams and constructional details for remodeling old audio amplifiers for operation with screen-grid tubes. THORDARSON ELECTRIC MFG. CO.

131. THE MERSHON CONDENSER—Two illustrated booklets giving the theory and uses of the electrolytic condenser. AMRAD CORPORATION.

132. THE NATIONAL SCREEN-GRID SHORT-WAVE RECEIVER—Constructional and operating data, with diagrams and photographs. JAMES MILLEN.

133. THE NATIONAL SHIELD-GRID FIVE—A circuit diagram with constructional and operating notes on this receiver. JAMES MILLEN.

134. REMLER SERVICE BULLETINS—A regular service for the professional set builder, giving constructional data, blueprints, and hints on marketing. GRAY & DANIELSON MFG. CO.

135. THE RADIOBUILDER—A periodic bulletin giving advance information, constructional and operating data on S-M products. SILVER-MARSHALL, INC.

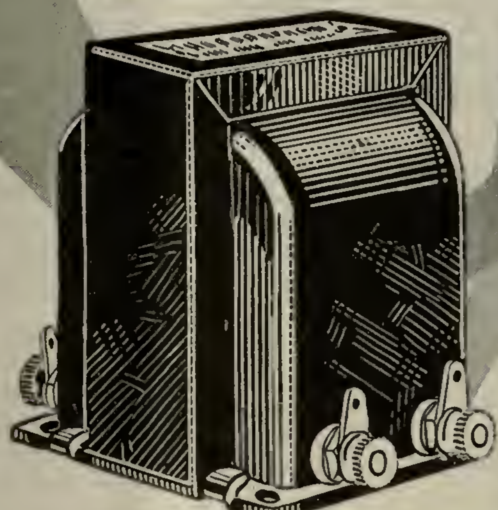
136. SILVER MARSHALL DATA SHEETS—These data sheets cover all problems of construction and operation on Silver-Marshall products. SILVER-MARSHALL, INC.

139. POWER UNIT DESIGN—Periodical data sheets on power unit problems, design, and construction. RAYTHEON MFG. CO.

140. POWER UNIT PROBLEMS—Resistance problems in power units, with informative tables and circuit diagrams. ELECTRAD, INC.

141. AUDIO AND POWER UNITS—Illustrated descriptions of power amplifiers and power supplies, with circuit diagrams. THORDARSON ELECTRIC MFG. CO.

A NEW NOTE IN AUDIO AMPLIFICATION



THORDARSON R-300 AUDIO TRANSFORMER

SUPREME in musical performance, the new Thordarson R-300 Audio Transformer brings a greater realism to radio reproduction. Introducing a new core material, "DX-Metal" (a product of the Thordarson Laboratory), the amplification range has been extended still further into the lower register; so that even the deepest tones now may be reproduced with amazing fidelity.

The amplification curve of this transformer is practically a straight line from 30 cycles to 8,000 cycles. A high frequency cut-off is provided at 8,000 cycles to confine the amplification to useful frequencies only, and to eliminate undesirable scratch that may reach the audio transformer.

When you hear the R-300 you will appreciate the popularity of Thordarson transformers among the leading receiving set manufacturers. The R-300 retails for $8.00.

THORDARSON ELECTRIC MANUFACTURING CO.
Transformer Specialists Since 1895
WORLD'S OLDEST AND LARGEST EXCLUSIVE TRANSFORMER MAKERS
Huron and Kingsbury Streets — Chicago, Ill. U.S.A.

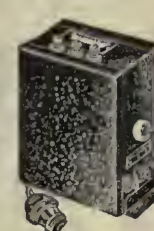
Power Supply Transformers

These transformers supply full wave rectifiers using two UX-281 tubes, for power amplifiers using either 210 or 250 types power amplifying tubes as follows: T-2098 for two 210 power tubes, $20.00; T-2900 for single 250 power tube, $20.00; T-2950 for two 250 tubes, $29.50.

Double Choke Units

Consist of two 30 henry chokes in one case. T-2099 for use with power supply transformer T-2098, $14; T-3099 for use with transformer T-2900, $16; T-3100 for use with transformer T-2950, $18.

Power Compacts



A very efficient and compact form of power supply unit. Power transformer and filter chokes all in one case. Type R-171 for Raytheon rectifier and 171 type power tube, $15.00; Type R-210 for UX-281 rectifier and 210 power tube, $20.00; Type R-280 for UX-280 rectifier and 171 power tube, $17.00.

Speaker Coupling Transformers

A complete line of transformers to couple either single or push-pull 171, 210 or 250 power tubes into either high impedance or dynamic speakers. Prices from $6.00 to $12.00.

Screen Grid Audio Coupler

The Thordarson Z-Coupler T-2909 is a special impedance unit designed to couple a screen grid tube in the audio amplifier into a power tube. Produces excellent base note reproduction and amplification vastly in excess of ordinary systems. Price, $12.00.

THORDARSON ELECTRIC MFG. CO.
500 W. Huron St., Chicago, Ill. 3583-J

Gentlemen: Please send me your constructional booklets on your power amplifiers. I am especially interested in amplifiers using.......................tubes.

Name..

Street and No...

Town.............................*State*..............

The *Radio Broadcast* LABORATORY INFORMATION SHEETS

THE aim of the Radio Broadcast Laboratory Information Sheets is to present, in a convenient form, concise and accurate information in the field of radio and closely allied sciences. It is not the purpose of the Sheets to include only new information, but to present practical data, whether new or old, that may be of value to the experimenter, set builder or service man. In order to make the Sheets easier to refer to, they are arranged so that they may be cut from the magazine and preserved, either in a blank book or on 4" x 6" filing cards. The cards should be arranged in numerical order.

Since they began, in June, 1926, the popularity of the Information Sheets has increased so greatly that it has been decided to reprint the first one hundred and ninety of them (June, 1926–May, 1928) in a single substantially bound volume. This volume, "Radio Broadcast's Data Sheets" may now be bought on the newsstands, or from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Inside each volume is a credit coupon which is worth $1.00 toward the subscription price of this magazine. In other words, a year's subscription to Radio Broadcast, accompanied by this $1.00 credit coupon, gives you Radio Broadcast for one year for $3.00, instead of the usual subscription price of $4.00.

—The Editor.

No. 225 Radio Broadcast Laboratory Information Sheet October, 1928

Calculating Grid Bias for A.C. Tubes

CORRECT RESISTANCE VALUES

IN ALL a.c. receivers, grid bias for the various tubes is obtained by connecting resistances of the correct value at the correct point in the circuit. The calculation of the value of the resistance and its placement in the circuit have been the subject of quite a few letters written to the Technical Information Service and we have therefore devoted this Laboratory Sheet to the subject. The circuit diagrams of six combinations are given on Laboratory Sheet No. 226.

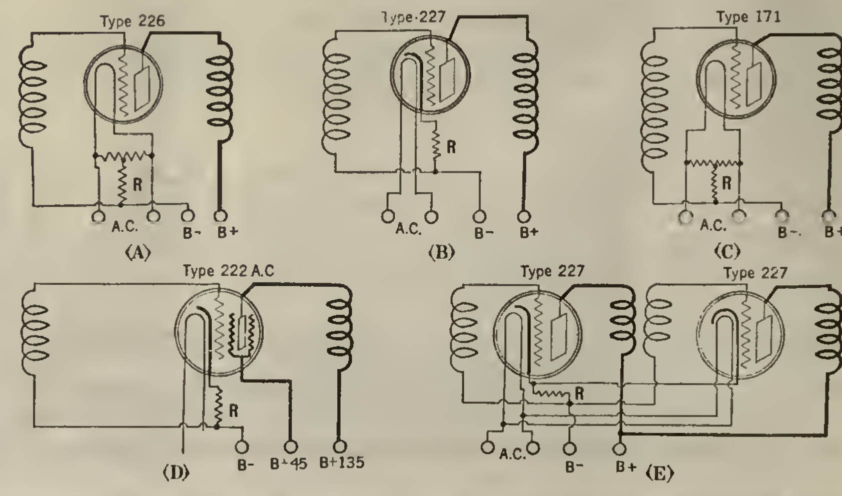
If these diagrams are examined one important point will be noted, which is that the resistance, R, which supplies C bias to the tube, is always connected between the center of the filament, or the cathode in the case of heater type tubes, and negative B. The resistance is placed in this position in relation to the circuit no matter what tube or combination of tubes is used. With the resistor in this position the plate current of the tube must go through it in order to reach the filament, or cathode, and therefore the voltage drop across the resistance is equal to the plate current times the resistance in ohms. To calculate the value of resistance, we must therefore know the value of grid bias that we desire to obtain and also the plate current flowing through the resistance. For example, in diagram A we have indicated a 226 type tube. By reference to any table of tube characteristics we can determine that the 226 type tube with 90 volts on the plate requires a grid bias of 6 volts and the plate current is 3.5 milliamperes. R is found by dividing the grid voltage required, 6, by the plate current in amperes, 0.0035, which gives a value of 1700 ohms as the required value of resistance.

In diagram C, a 171 tube is used, forty volts of grid bias are required if the plate voltage is 180 volts. The plate current under such conditions is 20 milliamperes, and 40 divided by 0.02 amperes gives 2000 ohms as the value of resistance required for C bias.

If a circuit utilizes more than one tube of the same type for which we require the same value of grid bias, the circuit is arranged as indicated at E, in which case the plate current of both of the tubes flows through resistance R. If the plate voltage on the 227 type tube is 90, the plate current is 3.7 milliamperes and the required grid bias is 6 volts. The grid bias resistance is then equal to 6 divided by 7.4 (the total current of the two tubes) which gives 800 ohms as the correct value for R.

No. 226 Radio Broadcast Laboratory Information Sheet October, 1928

Grid Bias Circuits for A.C. Tubes



No. 227 RADIO BROADCAST Laboratory Information Sheet October, 1928

The Audio Transformer

THE EFFECT OF ITS INDUCTANCE

THE diagram on this sheet indicates at A a single stage of audio-frequency amplification; B is the equivalent circuit, in which E_g is the signal voltage in the plate circuit, L_a is the leakage reactance of the transformer, L is the inductance, and C is the distributed capacity of the secondary and the tube input capacity, transferred to the primary. R_p is the plate resistance of the tube. Let us study this circuit to see what happens at various frequencies. The treatment given below is not exact but is approximately correct.

At low frequencies the reactance of C in comparison with L is very large and the reactance of L is very large in comparison with that of L_a. Therefore at low frequencies the voltage in the plate circuit divides between L and R_p. The voltages across these two parts of the circuit are 90 degrees out of phase and the percentage of the total voltage that appears across L depends upon the ratio of the reactance of L to the resistance of R_p, and varies as indicated in the second column in the table, column 1 being the ratio of the reactance of L to the resistance, R_p.

Now suppose that we desire to work the transformer out of a 201A-type tube with an R_p of about 11,000 ohms and that at 60 cycles we want to utilize at least 70 per cent. of the total voltage. Then, from the table we will have to make X_L, reactance of the coil L at 60 cycles, equal to the resistance of the tube. Therefore:

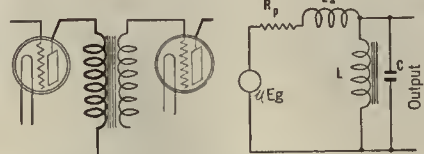
$$X_L = 11{,}000$$
$$2\pi fL = 11{,}000$$
$$6.28 \times 60 \times L = 11{,}000$$
$$L = 30 \text{ henries}$$

We might look at the problem in another way. Suppose we desire a transformer with a voltage drop at 60 cycles of not more than 1 TU. When a circuit is 1 TU down in voltage, the actual voltage loss is about 11 per cent., leaving 89 per cent. This corresponds to a ratio of X_L over R_p of 2. Therefore, from the table the reactance of L at 60 cycles must be twice the resistance of the tube or 22,000 ohms.

$$2\pi fL = 22{,}000$$
$$L = 59 \text{ henries}$$

TABLE

$\frac{X_L}{R}$	*Percentage of total voltage across L*
4.0	97
2.0	89
1.0	71
0.5	44.6
0.3	28.7



(A) (B)

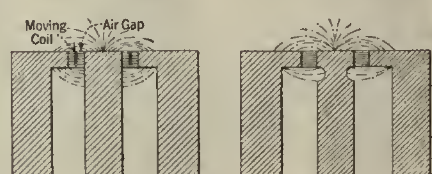
No. 228 RADIO BROADCAST Laboratory Information Sheet October, 1928

The Dynamic Loud Speakers

THE FIELD MAGNET

THE dynamic-type loud speaker depends for its operation on the production of a very strong magnetic field in the air-gap in which the moving coil is placed. This air-gap is indicated in the sketch on this sheet. The useful magnetic flux is that indicated by the light solid lines flowing directly across the gap, and the leakage flux—that part of the magnetic field which serves no useful purpose—is indicated by the dot-dash lines.

The flux which any given amount of magnetic material, such as iron or steel, can handle efficiently is definitely limited by saturation. When the iron is saturated its resistance—reluctance is the technical term—to the flow of magnetic lines through it increases and then the leakage flux increases. The flux will tend to take that path which has the lowest reluctance. To prevent leakage the pole pieces are frequently shaped in some peculiar manner, such as indicated at B, in order that the actual air-gap will be a very much lower reluctance path for the flux than any other path. The leakage flux in sketch A does not have to travel a path much longer than the actual air-gap, i.e., the two paths have about the same reluctance. In the pole shape indicated at B the flux path outside the air-gap is much longer than the path through the air-gap. The latter arrangement therefore tends to reduce the leakage flux.



(A) (B)

Assuming that the iron does not saturate, the flux in the air-gap will increase very rapidly as the size of the gap is decreased, and in practice the gap is always made as small as possible, leaving just sufficient room for the coil to move without any danger of its striking the pole pieces.

No. 229 RADIO BROADCAST Laboratory Information Sheet October, 1928

The Telephone Transmission Unit

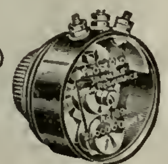
No. of TU	Power Ratio		No. of TU	Power Ratio		No. of TU	Power Ratio		No. of TU	Power Ratio	
	Gain	*Loss*		*Gain*	*Loss*		*Gain*	*Loss*		*Gain*	*Loss*
0.1	1.023	.977	2.7	1.862	.537	5.3	3.39	.295	7.9	6.17	.162
0.2	1.047	.955	2.8	1.906	.525	5.4	3.47	.288	8.0	6.31	.158
0.3	1.072	.933	2.9	1.950	.513	5.5	3.55	.282	8.1	6.45	.155
0.4	1.096	.912	3.0	1.995	.501	5.6	3.63	.275	8.2	6.61	.151
0.5	1.122	.891	3.1	2.04	.490	5.7	3.72	.269	8.3	6.76	.148
0.6	1.148	.871	3.2	2.09	.479	5.8	3.80	.263	8.4	6.92	.144
0.7	1.175	.851	3.3	2.14	.468	5.9	3.89	.257	8.5	7.08	.141
0.8	1.202	.832	3.4	2.19	.457	6.0	3.98	.251	8.6	7.24	.138
0.9	1.230	.813	3.5	2.24	.447	6.1	4.07	.245	8.7	7.41	.135
1.0	1.259	.794	3.6	2.29	.437	6.2	4.17	.240	8.8	7.59	.132
1.1	1.288	.776	3.7	2.34	.427	6.3	4.27	.234	8.9	7.76	.129
1.2	1.318	.759	3.8	2.40	.417	6.4	4.37	.229	9.0	7.94	.126
1.3	1.349	.741	3.9	2.45	.407	6.5	4.47	.224	9.1	8.13	.123
1.4	1.380	.724	4.0	2.51	.398	6.6	4.57	.219	9.2	8.32	.120
1.5	1.413	.708	4.1	2.57	.389	6.7	4.68	.214	9.3	8.51	.118
1.6	1.445	.692	4.2	2.63	.380	6.8	4.79	.209	9.4	8.71	.115
1.7	1.479	.676	4.3	2.69	.372	6.9	4.90	.204	9.5	8.91	.112
1.8	1.514	.661	4.4	2.75	.363	7.0	5.01	.200	9.6	9.12	.110
1.9	1.549	.645	4.5	2.82	.355	7.1	5.13	.195	9.7	9.33	.107
2.0	1.585	.631	4.6	2.88	.347	7.2	5.25	.191	9.8	9.55	.105
2.1	1.622	.617	4.7	2.95	.339	7.3	5.37	.186	9.9	9.77	.102
2.2	1.660	.603	4.8	3.02	.331	7.4	5.50	.182	10.0	10.00	.100
2.3	1.698	.589	4.9	3.09	.324	7.5	5.62	.178	20.0	100	.01
2.4	1.738	.575	5.0	3.16	.316	7.6	5.75	.174	30.0	1,000	.001
2.5	1.778	.562	5.1	3.24	.309	7.7	5.89	.170	40.0	10,000	.0001
2.6	1.820	.550	5.2	3.31	.302	7.8	6.03	.166	50.0	100,000	.00001

Another huge achievement by

FROST-RADIO

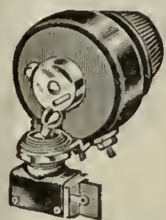
----a complete line of these famous radio parts

Frost-Radio has scored another of its characteristic achievements in bringing out a number of new items to supplement its already famous line of parts. Frost now offers the finest and most complete line of radio parts of any manufacturer in the field. Whether you build sets for yourself or for others you will find in this great line practically all of the vital and important parts you require. Your favorite dealer can supply you. Why not get in touch with him today?



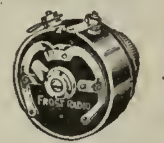
Frost-Radio Variable High Resistances

Offer marvelous control of volume and oscillation. Roller contact arm is practically frictionless. Bakelite case and dust cover. Supplied in a wide range of resistances. $2.00 and $2.25.



Equipped With Approved AC Switch

Underwriters' approved AC snap switch fitted to our Variable High Resistance makes ideal combination. Switch is tested to carry 250 volts at 3 amperes. $2.75 and $3.00.



Frost-Radio Variable High Resistance with DC Switch

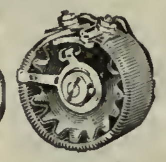
Another combination of the Frost Variable High Resistance with quick-operating switch having positive "off" position, for use only with battery operated sets. Switch has sterling silver contacts, with German silver springs, and Bakelite insulation is used. $2.35.

Frost Gem Variable High Resistance

Identical with our larger Resistance Units except in size. The Gem is housed in Bakelite case measuring 1⅝ x ⅝ in., thus saving much space back of panel. $2.25 and $2.50.

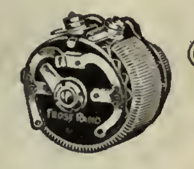
Frost-Radio Gem Rheostats

Mighty good little rheostats, built to give long service and stand the gaff. Take up but little space, are single hole mounting and are easy to solder to. Supplied plain or with DC switch, the latter offering a remarkable combination at minimum cost, as it combines both rheostat and switch. Plain type, 75c. With switch, $1.00.



Frost-Radio Bakelite Rheostats

The original aircooled Bakelite rheostat with one-piece moulded frame and resistance wire wound on threaded flexible Bakelite strip. Supplied in a wide range of resistances, $1.00. Potentiometers, $1.25 to $2.50.

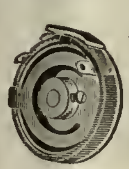


Frost-Radio Bakelite Rheostat with Switch

Battery operated sets find wonderful service in these Frost Rheostats with switch mounted on Bakelite panel. Switch has positive "off" position, and springs are German silver with sterling silver contacts, 2 to 75 ohms, $1.35.

Frost-Radio AC Snap Switch

Approved, single hole mount AC switch 3 amp., 250 v., 75c.



Frost-Radio Hum Balancer

Ideal for smoothing the ripple out of AC current. Easy to regulate with screw driver by means of slotted head shaft, $1.00.

Frost-Radio Bakelite Cable Plug

A remarkable achievement in an all-Bakelite Cable Plug. Terminals are spun into sockets and cannot work loose even when overheated in soldering. Color code molded into Bakelite. Plug is equipped with 5-ft. seven wire braid covered cable with best rubber insulation on individual wires. Plug and cord only, $2.25. Baseboard or sub-panel socket, 75c.

Frost-Radio Moulded Mica Condensers

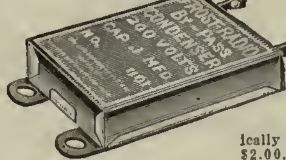
Finely made and extremely accurate. Guaranteed to within 10%. Unaffected by moisture or climatic changes. Molded Bakelite, with finest quality mica dielectric. Neat, small, easy to attach either to metal subpanel or by means of soldering lugs, 45c to 90c.

Frost-Radio Fixed Resistances

Windings are on die cut flexible Bakelite strip, with firmly staked terminals. .4 to 1000 ohms. Also as center tapped resistances to provide grid return in AC sets, 6 to 64 ohms. 15c to 50c.

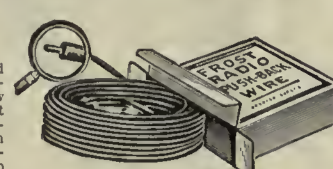
FROST-RADIO UNIVERSAL RESISTANCE KIT

Consists of four 2000 ohm potentiometers, three 2000 ohm fixed resistors and one 1500 ohm fixed resistor. Supplies voltages 0 to 30, 30 to 50, 50 to 70, 90, 135, and 180. Resistors fitted with sliding connections. Complete kit (not illustrated), $9.00.



Frost-Radio By-Pass Condensers

Accurate capacities and conservative voltage ratings distinguish these new Frost Condensers. Built of best materials, thoroughly seasoned, vacuum impregnated and hermetically sealed. .1 to 2 mfds. 80c to $2.00.



Frost-Radio Hook-Up Wire

Simply push back the braid for soldering, and slide it back over the soldered joint. No. 18 double cotton covered, impregnated wire. 50 ft. roll, 80c.

Frost-Radio 210 Blocking Condensers

Built to give super-service, with conservative voltage ratings. Every item of material used in their construction is the very best obtainable. Enclosed in hermetically sealed cases of gold-bronze lacquered metal, with tinned terminals. The best Blocking Condensers money can buy. $18.00.

Frost-Radio Heavy Duty Filter Condensers

Like our Blocking Condensers, Frost Filter Condensers are a quality product, made of the finest linen paper and highest grade foil. Conservatively rated. Will give long service. .5 to 2 mfds, $1.40 to $7.00.

"WORTH MANY TIMES 10c TO ANYONE WHO IS INTERESTED IN RADIO"—Send for this 16-page book today.

Those who have sent for the new Frost Data Book tell us it is worth many times the dime asked for postage and mailing. It contains a vast amount of valuable information—tells also about the complete Frost-Radio line — YOU should have a copy. Fill out and mail coupon today.

HERBERT H. FROST, INC.

Main Office and Factory: ELKHART, IND.

New York City — CHICAGO — San Francisco

HERBERT H. FROST, Inc. *RB10*
160 No. La Salle Street, Chicago

Send me your new Frost Data Book, containing not only valuable radio information, but also facts about your new line. I enclose 10c.

(Are you a professional set builder?........................)

Name ....

Street Address ....

City .... State ....

No. 230 RADIO BROADCAST Laboratory Information Sheet October, 1928

Filters

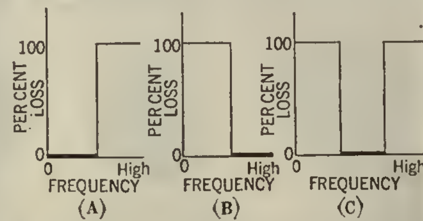
HOW THE VARIOUS TYPES DIFFER

IN TELEPHONE and radio circuits various types of filters are used and in this Laboratory Sheet we will indicate how the several types differ.

First let us define a filter. We might say that a filter is a circuit arrangement that will separate direct current from alternating current or vice versa or a circuit that will separate alternating currents of one or a group of frequencies from alternating currents of a different frequency or group of frequencies.

Filters can be divided into three general classes: (A) low pass filters; (B) high pass filters; (C) band pass filters.

Low pass filters. A low pass filter is designed to pass all the low frequencies below a certain cut-off frequency and to oppose the passage of frequencies above the cut-off frequency. The frequency characteristic curve of an ideal low pass filter is given in sketch A. The r.f. choke coil used in the plate circuit of a detector tube functions as a low pass filter, since it permits audio frequencies to pass into the audio amplifier but excludes from the amplifier the high carrier frequencies.



High pass filters. Sketch B gives a frequency characteristic of an ideal high pass filter and it will be noted that it has the opposite effect to a low pass filter in that it permits the passage of high frequencies and obstructs the flow of low frequencies. The r.f. chokes and condensers used in the plate circuits of an r.f. amplifier are an example of a high pass filter, functiong to pass the high frequencies directly to the filament, thereby keeping them out of the plate supply, but obstructing the passage to the filament of the d.c. plate current (which can be considered a current of o frequency).

Band pass filters. This type of filter permits the passage of a band of frequencies and excludes all those frequencies below or above this band. A very common type of band pass filter is used in radio receivers—the tuned circuit. When a coil-condenser combination is tuned to a given broadcasting station it permits the passage of that band of frequencies associated with that broadcasting station and excludes to a more or less greater degree frequencies either lower or greater than that of the station we are trying to receive. The ideal curve of a band pass filter is indicated in sketch C.

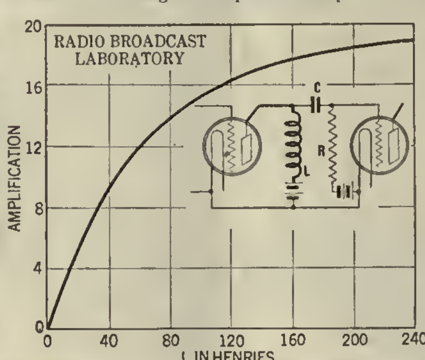
No. 231 RADIO BROADCAST Laboratory Information Sheet October, 1928

Impedance-Coupled Amplifiers

THE EFFECT OF THE SIZE OF THE INDUCTANCE

IN CONNECTION with impedance-coupled audio amplifiers, the statement is frequently made that the coupling inductances should have as large an inductance as possible, creating the impression thereby that the larger the inductance the better the results. Such is not the case. First, let us examine the effect of the inductance at low frequencies.

The curve on this sheet indicates how the amplification from a stage of impedance-coupled audio varies with the inductance in henries of the coupling coil, L. This curve is calculated for a frequency of 60 cycles, assuming that this is the lowest frequency which we desire to amplify uniformly. It is assumed that the tube has a plate impedance of 30,000 ohms and a mu of 20, and that the coupling condenser, C, and the grid resistance, R, are of such values as not to affect the amplification. If 100 per cent. amplification were obtained, the gain would be 20, and with an infinitely high inductance this gain might be realized at low frequencies. With practical values of inductance, however, the gain is less than this and varies with the inductance as indicated by this curve.



The value of the coupling inductance should be the smallest value that will give satisfactory gain at the lowest frequency to be amplified, which we have assumed in this case to be 60 cycles. At medium frequencies the amplification obtained from a circuit of this sort is approximately equal to the amplification constant of the tube and we might assume as a reasonable figure that the amplification at 60 cycles shall not be less than 75 per cent. of the amplification obtained at medium audio frequencies. 75 per cent. of 20 is 15, the value therefore of the gain at 60 cycles. This corresponds to an inductance of 100 henries.

If a value of inductance much greater than this is used to obtain more amplification at low frequencies, it will be found that the high frequencies begin to fall off due to the shunting effects of the tube and coupling coil capacities. Amplifier curves with various values of coupling impedance will be given and explained in a future Laboratory Sheet.

No. 232 RADIO BROADCAST Laboratory Information Sheet October, 1928

The Voltmeter

HOW IT WORKS

IN PRECEDING Laboratory Sheets, Nos. 205, 214 and 222 we explained the construction of the galvanometer and the ammeter and indicated how they differed. The voltmeter is quite similar to these two instruments, differing in only one important respect to be explained below.

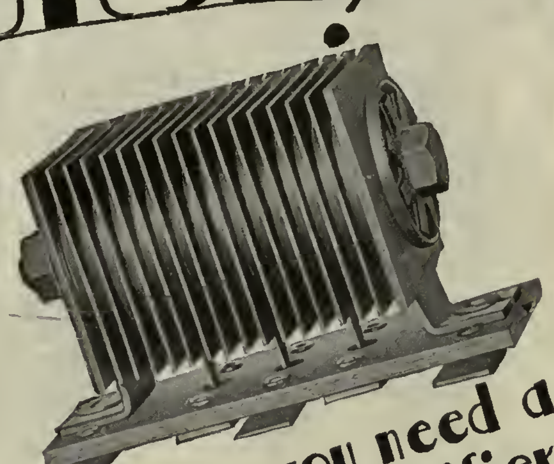
A voltmeter is used obviously to measure voltage. We desire to measure this voltage using as little power as possible, for if the instrument itself requires any great amount of power it is liable to affect the voltage reading of units such as batteries or B-power units which are designed to deliver only a small amount of power.

To measure the voltage of some source of potential we might take a very low reading ammeter, one having a maximum scale reading of perhaps 0.01 amperes, place it in series with a known high resistance and then connect it across the source of potential. The ammeter would read the current that flowed and then by Ohm's law, which states that the voltage is equal to the current times the resistance, we could calculate the value of the voltage.

In a voltmeter this high resistance is permanently connected inside of the instrument and the scale is calibrated to read volts instead of amperes. In other words we might say that the instrument solves Ohm's law for us and makes it unnecessary to calculate the IR drop every time we wish to measure a voltage.

Ammeters and voltmeters may in general be distinguished in one other way other than the fact that they are marked "volts" or "amperes" on the scale of the instrument. It will generally be found that ammeters have fairly large terminals and they are generally of metal. Voltmeters have small terminals and they are always of the insulated type. Ammeters are equipped with metal terminals because no damage results to the instrument or the circuit in which it is connected if the terminals are accidently short-circuited; ammeters are always connected in series with a circuit and have a very low resistance, so that shorting them affects the circuit very little. Voltmeters, on the other hand, are always connected *across* the source of potential, and if the voltmeter terminals are accidentally short-circuited then the source of potential is short-circuited. A short-circuit may not be a serious thing when measuring a B battery, but may cause damage if it occurs when measuring the voltage at a light socket or when measuring the output voltage of a large generator.

PEP UP YOUR SET!



Replace your Balkite Acid Jar with the Authorized Solid, Dry ELKON Replacement Unit.. Get away from Acids, Water, Corrosion, Trouble..

Perhaps you need a New Elkon Rectifier

If your set hasn't the same pep and kick it did when you first installed your "A" Eliminator, you need a new Rectifier in the "A" Eliminator. And you are lucky if you have a Majestic, Elkon, Knapp, Fada, Sentinel, Webster, Metro and many others for then you can slip the old rectifier off, and put in a new Elkon Replacement Rectifier in less time than it takes to read this. And the old eliminator is as good as it ever was! *Buy one today from your dealer.*

If your trickle charger isn't keeping the battery up as well as it did when you bought it—buy a set of Elkon replacement rectifiers and it will be as good as it ever was. Elkon Type V-4 replacement Units can be placed in Acme, Elkon, National, Cleveland, Precision, Bernard. Today's a mighty good time to pep up the old charger—see your dealer.

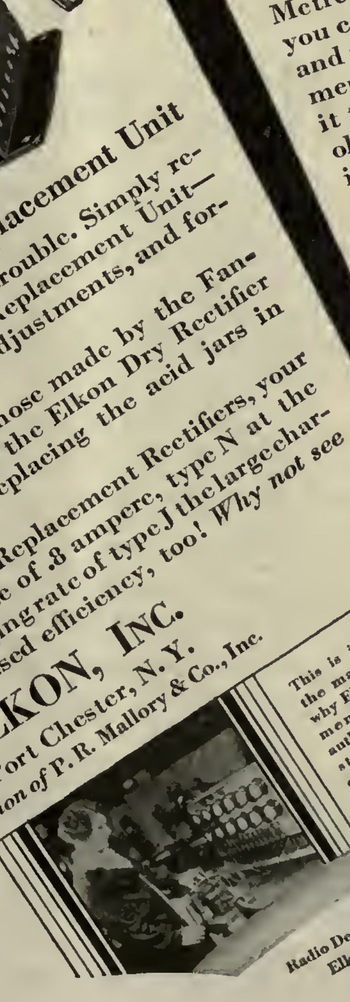
BUY ELKON—The *Authorized* Replacement Unit

Throw away the acid jar! No more fuss, mess, trouble. Simply remove the Acid Jar and snap in the Elkon Replacement Unit—Solid—dry—self healing—no attention or adjustments, and forget it for 5000 hours.

The Elkon Replacement Units and those made by the Fansteel Products Company containing the Elkon Dry Rectifier *are the only ones* authorized for replacing the acid jars in Balkite Power Units.

With the Elkon Self-Healing Replacement Rectifiers, your type K will charge at the rate of .8 ampere, type N at the rate of 1 ampere. The charging rate of type J the large charger, is raised 20%. Increased efficiency, too! *Why not see your dealer today!*

ELKON, INC.
Port Chester, N.Y.
Division of P. R. Mallory & Co., Inc.



This is just one of the many reasons why Elkon Replacement Units are authorized by Fansteel—Accurate, careful testing of every Rectifier.

Radio Department,
Elkon, Inc., Port Chester, N.Y.
290 Fox Island Road.
Send me complete information on Elkon Radio Products.
Name..........
Address..........

AUSTRIA'S PRESIDENT SIGNS A "FULTOGRAPH"

Dr. Siepel, President of Austria, is at the left, signing a photograph of himself transmitted by radio by the method perfected by Captain Otho Fulton (in the center, with his hand on the table). Captain Fulton developed his apparatus, the "Fultograph", in Vienna; the British Broadcasting Company is now considering its adoption.

Photo Broadcasting in England

By WILLIAM J. BRITTAIN

REGULAR broadcasting of pictures is promised for Great Britain by October. The British Broadcasting Corporation is now considering the adoption of the "Fultograph," the apparatus of Captain Otho Fulton, an Englishman who has been experimenting in Vienna for three years.

Captain Fulton gave me a demonstration of his apparatus when I met him in Vienna. The photograph to be transmitted is printed on a copper foil coated with sensitized fish glue. Exposure to light makes part of the glue surface insoluble. Washing removes the soluble parts, which have not been exposed to light, and a half-tone picture in glue is left.

The foil is then placed on the transmitting machine. All you can see is a box containing a small clockwork motor, and at the side a cylinder which can move slowly round, like the one on Edison's first phonograph. The foil is wrapped round the cylinder, which is then set going. Over the foil a metal needle passes.

When the needle is touching a part of the bare foil a current passes and is transmitted. When it touches a part where the glue is, the glue acts as an insulator, and no current passes.

In receiving the picture broadcasts a one-tube set is sufficient for distances within a mile of the broadcasting station; for greater distances a receiver of two or more tubes is necessary.

You can hardly tell the receiving set from that at the transmitting end. Round the brass cylinder a piece of paper dipped in chemicals, and still damp, is placed. A platinum needle passes over it, and when current is being sent out at the transmitting end a current passes between the needle and the cylinder, and the paper is stained brown through the action of the current on the sensitized paper. Thus the picture is traced out.

In his early experiments, Captain Fulton told me, he synchronized reception and transmission by means of a pendulum device devised by himself and Mr. T. Thorne Baker, of London, with whom he formerly collaborated. Both receiving and transmitting instruments were fitted with a long pendulum which made an electric contact at every beat of 1½ seconds and released the cylinders for a new revolution.

With this method it was found that unless there was absolute stability, the picture was ruined; so now Captain Fulton has devised a series of relays giving him electro-magnetic synchronization. This enabled him in a test to take his apparatus on a ten-day steamboat trip along the Danube and receive pictures from his laboratory in Vienna during the entire trip.

The fact that the glue on the copper foil is easily scratched calls for some remedy. One is to "burn in" the picture; another, used by Thorne Baker, is to roll the glue picture between polished steel, so that the picture sinks into the metal, like a picturesque commutator.

For the chemicals in which the semi-absorbent paper is dipped, several mixtures are used. One is a potassium iodide and starch solution, which gives a coloration with the passage of a current of less than two milliamperes; and another solution, used in the Jenkins laboratories, contains ammonium nitrate, ammonium chloride, and potassium ferrocyanide.

"All the time I have tried to simplify radio picture apparatus for the man at home," Captain Fulton told me. "I consider my latest apparatus is as simple as a cart: a cart has only the wheels and the body, and if you take either away it isn't a cart any more. My assistants and I have worked hard and now we have made a home set to be sold to the public for about seventy-five dollars. They have already been adopted in Vienna."

The pictures are 4½ inches by 3½ inches, and those I saw received were as distinct as hurriedly produced newspaper photographs.

Letters from Readers

The Last Word

WHAT appears to be the final answer to the questions that arose over the meaning of Greenwich Mean and Greenwich Civil Time, as used in the list of short-wave stations in the May issue, has come from Captain C. S. Freeman, U. S. N., Superintendent of the U. S. Naval Observatory. The necessary corrections for the errors which occurred in the original list appeared in this column in the August issue, but we appended a request for information as to whether there was any recognized system of time computation which used a day starting at noon. Captain Freeman answers:

To the Editor:

There is no longer any time in use by which the day is reckoned as beginning at noon. That kind of day was called the astronomical day, and was used principally by astronomers, navigators, and persons engaged in longitude determinations. In making their computations, the above mentioned persons used data from the national ephemerides (astronomical ephemerides). Beginning in 1925, all the national ephemerides discontinued the use of the astronomical day, and all users of these publications changed accordingly.

It would have been better probably if the term "Mean Time" had not been continued in use in referring to the day beginning at midnight. However, its use has not been due to confusion in the minds of the users, since among them are the astronomers and time authorities of Europe, who undoubtedly understand the significance of the terms involved.

The matter may be summed up as follows: Greenwich Mean Time (G. M. T.) and Greenwich Civil Time (G. C. T.) refer to the same system of time computation, the first being the European designation and the second the American designation. This system of computation begins its day at midnight (o hours) in the longitude of Greenwich, England. No system in use to-day begins the day at noon.

Volunteer Proof Readers

IT SEEMS that our embarrassment in the September issue over the presence of errors in these pages has inspired several readers, ambitious for the position of million-dollar proof reader, to point out several other mistakes in the September number. However, since each of the two correspondents quoted below points out only one error, and fails to find the error noted by the other, the lucrative position in the proof room remains vacant, and the firm is still holding on to the million dollars.

To the Editor:

After reading the article in the September RADIO BROADCAST on page 308 in regard to mistakes, I hardly have the heart to write you about a glaring error on page 253 of the same number. But really, your contributors, compositors and proof readers should know the difference between "flaunting" and "flouting." It seems rather strange, but almost every time I have seen the word "flaunting" used recently, especially in the daily press, the writer has actually meant "flouting." "Flaunting the constitution, (or the 18th amendment)" seems to be a favorite phrase with the newspaper writers.

I would suggest to the editor of every newspaper and magazine that a little notice be put up in the office to the effect that the words "flaunting" and "flouting" had better not be used at all. Then there will be no confusion between them.

B. R. WHITE, New York City

(*Continued on page 388*)

Letters from Readers

(*Continued from page 386*)

To the Editor:

In a spirit more of sorrow than of censure, I am writing to call your attention to what appears to be a grave discrepancy in a certain paragraph notice contained in the copy headed "Here and There" on page 255 of your September issue. And to think that said discrepancy should occur in the same issue in which the little article "Our Mistake" unfolds its shameful tale, is enough to make any lover of RADIO BROADCAST break down and weep. However, you evidently said your "prayer to the radio gods" with little or no faith, for, lo, the "letters are already commencing to come in". Which "ain't no way to pray"!

Now don't think for one moment that *I* discovered above mentioned error—for I didn't; I am chronically near-sighted and sadly afflicted with "neglectitis" when it comes to details—how I loathe the word! But one of our Argus-eyed announcers (he's lots of other things around here, too) sorrowfully pointed it out to me—"and to think it's in our dear ole RADIO BROADCAST too," he sobbed. And so, I hurried straightway to my typewriter and decided to call your attention to it *immediately*, thinking maybe you might wire that Mencken man that you'd found his "million-dollar-a-year proof reader", as that salary would come in right handy.

On Page 255 in September issue, you will note, in black and white, that the "cost of broadcasting the Republican National Convention through 42 stations amounted to $77,000, or a little over a dollar a *minute*." And right there we've got you! You mean *seconds*, of course. For had the Grand Old Party been on the air 72,000 *minutes* as you say, it would have sure been some convention, as it would have broadcast 1200 hours or 50 days. Beats the Democratic 1924 record by about 4 weeks solid.

GENE BROWN, (Station WBAL)
Baltimore, Md.

Furthermore, we ourselves have also discovered a few typographical pecadilloes, which we are not going to mention for the reason that we want to keep our job.

Java on the Air

FROM George E. Morcroft, Pittsburg, Pa., comes this interesting news of the new radiotelephone service between Holland and Java:

To the Editor:

In your September issue (page 256) I noted a little news excerpt in which you told of the opening of a high-frequency radiotelephone system between Holland and Java, but you were unable to give details "as the dispatch from abroad was garbled."

If you are interested in further information as to these stations I would like to say that the Dutch station involved is PCLL at Kootwijk, Holland, on a frequency of 16,300 kc. with a power input of 32 kilowatts. I have often received this station and have had reception confirmed. The Java end is taken care of by two transmitters which are modulated at the same time, according to a letter I have just received from the Chief of the Radio Laboratory at Bandoeng, Java, confirming my reception of one of these stations, ANH. The two transmitters are ANH, at Malabar, Java, on a wavelength of 17.0 meters, and ANE at Bandoeng, Java, on 15.93 meters. The letter from Java also contains the information that music is broadcast several days a week from ANE on a wavelength of 15.93 meters from 1300 G. C. T. to 1750 G. C. T. (8 A. M.—12:50 P. M.—Eastern Standard Time). The telephone communications are carried on on Tuesdays and Thursdays from 1500 G. C. T.—1700 G. C. T. (10 A. M.—12 noon E. S. T.). PCLL at Kootwijk, Holland, also

(*Continued on page 390*)

EBY

Top view showing built-in guide for tube prongs

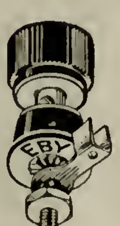
Bottom view without base showing contacts

SOCKETS

Eby Sockets have

1. Good looks that will improve the appearance of any set.
2. Grooved tops to guide tube prongs.
3. New and improved prongs providing long, tight spring contact. High current carrying capacity and low interelectrode capacity. Ideal for use with A. C. tubes.

List price UX type 40 cents
UY type 50 cents



BINDING POSTS

Eby Binding Posts are all that binding posts could be. Completely insulated with non-removable tops engraved in popular markings.

TIP JACKS

Eby Tip Jacks have countersunk tops so that the pin can't wobble. Equipped with red and black Bakelite washers for insulating from metal panels. List price 25 cents per pair.

The H. H. EBY MFG. CO., Inc.
4710 Stenton Ave. Philadelphia, Pa.

The New Knapp "A" Power Kit

This is the "A" power after you have assembled it. A professional job! Operates on 105 to 120 volts, 50 to 60 cycles AC. Supplies rippleless DC current for operating any set using Standard 5 or 6 volt tubes and power tubes.

Greater Efficiency—

Improved Design and Appearance—Lower Price—Money-making Plan for Set-Builders

You radio fans who made my "A" power the largest selling "A" power last spring have made it possible for me to offer the finest "A" Power ever developed—in Kit form—even more complete than before. Study the illustrations—read the improvements—and you will wonder how I was able to reduce the price. You are the answer. I sold 5 times as many "A" Powers as I expected to—and this season I am counting on you to help me again by buying even more.

The 8 Improvements

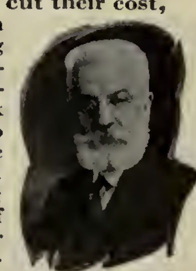
1. Larger Filter System—3 Elkon Condensers instead of 2. Ideal for Super Hets and Short Wave Sets.
2. Improved Choke Coils
3. Pendant Switch Controlling "A", "B" Eliminator & Set
4. Dial for regulating voltage
5. Celeron Front Panel
6. Baked finish
7. Heavier gauge metal cover
8. Die Cast Base Plate instead of wood

COMPLETE KIT—EASILY ASSEMBLED

Like my Kit last year, the New Knapp Kit is a tooled job—the parts seem to fall into place. Every hole is drilled—all that it is necessary for you to do is to put the screws and nuts in place and connect a few wires. Everything is supplied. Nothing for you to buy extra. The fool-proof instruction sheet makes it easy for anyone to assemble.

THE SET-BUILDER TAKEN CARE OF

You set-builders played with me (as the saying goes) and I am going to continue to play with you. My engineers have designed an "A" Power which is well-nigh perfect—my production men, based on tremendously large quantities have cut their cost, so that I can keep faith with you by reducing the cost. *And* regardless of what the established trade may think about it—I am going to continue to give you the maximum discounts. The coupon will bring you the full details of both the new "A" Power and the special discounts to set-builders.



David W. Knapp, *Pres.*

KNAPP ELECTRIC, Inc., Port Chester, N. Y.
—Div. P. R. Mallory & Co., Inc.—

Mr. David W. Knapp, *President,*
KNAPP ELECTRIC, Inc.,
334 Fox Island Road, Port Chester, N. Y.

Kindly send me complete information on the Knapp "A" Power and your special discounts for Set-Builders.

Name ....
Address ....
....

Letters from Readers

(*Continued from page 388*)

transmits musical programs 1300 G. C. T.—1650 G. C. T. (8 A. M.—11:50 A. M. E. S. T.) on Wednesdays.

Another Kruse Fan

IN THE September number we spoke of the enthusiasm accompanying the addition of Robert S Kruse to our list of authors. It hasn't stopped yet. To prove this we quote from a letter from Alphy L. Blais (VE-2AC—VE-2AS), Thetford Mines, P. Q.

To the Editor:

When R. S Kruse signed off from *QST*, I thought he was lost to the amateur world. It was a great and comforting surprise to meet him with the R. B. gang—still keeping on the same "amateur spirit." Gosh, I'm glad he's with us again—and that 5-meter band has got me in a trance. Give us more and more of it. R. S. K. has a way all his own to make one understand, and nobody can go wrong when following his instructions.

The radio work done here at VE-2AC, VE-2AS (O. R. S. of A.R.R.L.) is mostly amateur traffic handling on 20 and 40 meters. The 10-meter band is tackled with little results due to heavy local QRM.

I believe it would be very useful for us if R.B. were to give us an article on a frequency meter for the amateur bands. With the new laws coming in 1929 our old equipment goes kerplunk. Kruse is familiar with our wants and can give us a hand.

In 1923 I wrote to RADIO BROADCAST saying how good a magazine it was. In 1924 and 1925 also, especially commenting on Keith Henney and his "Home Lab." articles, unsurpassed so far. In 1926 and 1927 I wrote again giving you a cheer, and in 1928 it would take a book to write my praise. RADIO BROADCAST has reached a point where everything in it needs praise and no knocking. With *QST* you are the perfect magazine. Your advertising policy is very fine, and I side with you—no trash, only quality.

Wired Wireless

WIRED wireless is up for discussion again. On page 10 of our May issue we discussed editorially the probable place of wired wireless programs with respect to "space" or radio broadcasting of programs. Wired wireless has its place, but we feel that it does not yet offer serious competition to radio broadcasting. In St. Paul, Minnesota, as in several other communities in the Middle West, wired wireless programs are being offered commercially. The letter below is from a St. Paul resident whose name is omitted for obvious reasons.

To the Editors;

The St. Paul wired wireless system is comprised of a central receiving station where the programs are picked up on a well-designed receiver and then put over the land wires to the subscriber's home at high amplification. The subscriber has nothing but a speaker in his home, with some sort of resistance volume control.

The operator at the central station either picks the programs off the air, or, in the absence of suitable programs, puts on a little Orthophonic music for the subscribers—rather a limited service for $5.00 monthly! However, I am of the opinion that the A. T. & T. may furnish the St. Paul wired wireless concern with the blue and red networks of the N. B. C.

In talking over the wired wireless situation with fellow members of the radio trade, I have run into the argument of what will the advertiser do if wired wireless should predominate over the radio. In my opinion, the advertiser would be assured of a more regular audience than he is at

(*Continued on page 392*)

Letters from Readers

(*Continued from page 390*)

present able to get by radio with its weather and interference problems to contend with. Say that the subscriber had a choice of two national programs over his wired wireless installation, as is possible in one Minneapolis hotel, the chances are he would be more apt to be listening during weather that is ordinarily bad in radio, yet would not affect the telephone lines carrying his wired wireless programs to his home.

Radio can be greater than wired wireless could ever dream of, but its broadcasters must be progressive and not allow two or three chains to corner the entertainment features of the country. Because of a lack of power and talent on the part of Midwest broadcasters, we here must look to the chains and if it is the chains we must look to very long, the fickle public can be quickly won over to the possibilities of the telephone companies bringing these programs into their homes, free of static, interference, squeals, etc. To show you just why this would be so easy to bring about I give you a little idea of what the listener in these cities is up against.

Chicago, while close to us, is not heard regularly nor well enough, as a rule, to be termed consistent entertainment. Neither are Michigan broadcasters. Omaha and Des Moines, as a rule, come in like locals day or night but now devote most of their time to the red and blue chains of the N. B. C. With but few exceptions, our two best broadcasters spend their efforts toward rebroadcasting the chain programs. I have heard it said time and time again by the ardent radio fan that 95 per cent. of his listening time is devoted to listening to the chain features.

The recent action of Congress in really cutting down super-broadcasting has played into the hands of the big interests, who will some day attempt to put this wired wireless idea across, for unless we can have a sufficient number of super-broadcasters to cover the country, the advertisers will boycott the independent radio stations and in turn we face a loss of talent by these broadcasters for lack of financial support to put on their own broadcasting. The very life of the radio industry depends on a sufficient number of high-powered radio stations that can be heard consistently and with a greater variety of programs than is now possible for the average radio fan to obtain.

The radio industry should feel alarmed at the wired wireless situation before it becomes too late.

American Interference Patrols

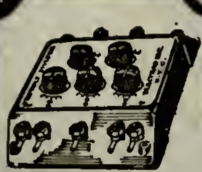
THAT the big light and power companies of this country are as anxious as the radio fan to remove the nuisance of man-made interference is evidenced by this letter from the Union Electic Light and Power Company, of Saint Louis:

To the Editor:

Our attention was first attracted to RADIO BROADCAST by its articles on radio interference, and in particular, the series of articles of Mr. A. T. Lawton. It was to receive this series of articles that our subscription was entered.

Our company has been quite interested and active since 1924 in locating and removing all sources of interference for which it is responsible. It has been somewhat discouraging at times when this service, rendered voluntarily, has been taken advantage of by many listeners and some dealers, who have blamed all their troubles on "leaky transformers." In most cases we have found this situation was caused by ignorance of the nature and source of interference. Many of the early articles on interference in magazines and newspapers strengthened this erroneous impression by the incorrect or misleading statements contained in them.

Such articles as those by Mr. Lawton are not only doing much to correct this misconception, but are also of great assistance to those who are earnestly trying to trace and eliminate interference. We hope to see more such articles.



U. S. Patent 1676869
and Patents Pending

Voltage Separation —the Secret of Perfect Eliminators

TRUVOLT DIVIDER

NOW! Electrad makes better eliminators possible with the TRUVOLT Divider. It separates output voltage so that you always get the right voltage in the right place. Saves complicated calculations, difficult wiring and the use of voltage regulator tubes. Simple—compact—easy to use.

List Price $12.50

Electrad Specializes in a Full Line of Resistance Controls for all Radio Purposes, Including Television.

Write for Free Circuit Data and Description of TRUVOLT DIVIDER.

Dept. MA-10, 175 Varick St.
New York

ELECTRAD Inc

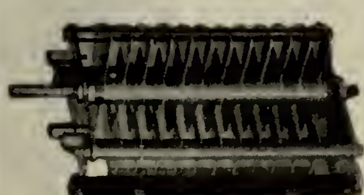
LOGIC . . .

RADIO communication is here to stay—

VARIABLE or other condensers are essential component parts of most installations—

CARDWELL CONDENSERS are built to stay with radio and to last for the life of your installation—

WHY putter?



Scores of special condensers may be found in course of construction at any time in the Cardwell Factory, engineered and designed for the foremost constructors of commercial transmitters and broadcasting stations. The regular CARDWELL line includes, as heretofore, the condensers most widely used and in demand.

What is your problem?

"There is a CARDWELL for every tube and purpose."

High Voltage Transmitting Condensers
Transmitting Condensers for Medium and Low Power
Air Dielectric Fixed Condensers
Receiving Condensers

LITERATURE UPON REQUEST

THE ALLEN D. CARDWELL MFG. CORPN.
81 PROSPECT ST., BROOKLYN, N. Y.

Goodwin
"VIVETONE 29"

Truly a Standard of Efficiency for A-C Operation

Manufacturers Whose Standard Parts Are Used in the "VIVETONE 29"

CORWICO
"BRAIDITE" HOOK-UP WIRE
EBY PATENTED
For Better Radio Hammarlund PRECISION PRODUCTS
JEWELL
BENJAMIN PRODUCTS
THORDARSON
Centralab
YAXLEY
WARD-LEONARD
DUBILIER Devices
Reg. U.S. Pat. Off.
DAVEN

DRILLED AND ENGRAVED WALNUT MICARTA PANELS FOR THE "VIVETONE 29" ARE AVAILABLE

HERE is a receiver that embodies to the highest degree those five features of paramount importance, namely—Sensitivity, Selectivity, Quality Reproduction, Beauty of Appearance and Simplicity of Construction with resulting Ease of Operation. In measuring up to these five necessary requirements the Goodwin "Vivetone 29" is truly a standard of efficiency.

All the parts used in the "Vivetone 29" are made by radio's most reliable and reputable manufacturers. Each part sets the standard in its line and is recognized as such by radio's leading engineers. The use of these quality parts in the "Vivetone 29" insures long and satisfactory service.

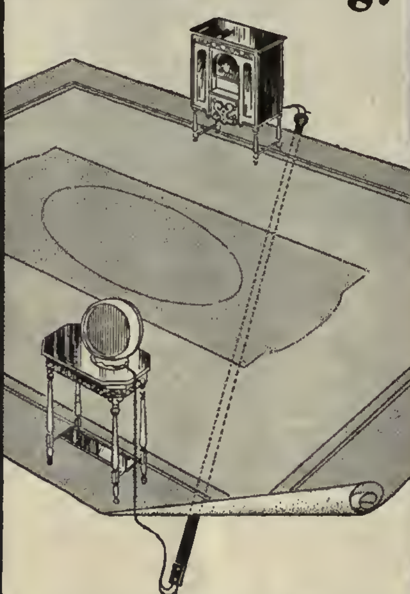
The constructor and commercial set builder can purchase all the parts used in the "Vivetone 29" from any dependable dealer.

BLUE PRINTS
FOR THE "VIVETONE 29"

Send today for the four complete full sized constructional blue prints incorporating every detail for the construction of the "Vivetone 29." Enclose $1.00 to cover cost of mailing and the actual cost of the blue prints.

Goodwin Radio Research Lab.
167 Glenwood Ave. Jersey City, N. J.

New! A Speaker Extension Cord that Lies Flat on the Floor Under the Rug!



Put your set and loudspeaker anywhere. Place them as far apart as you wish. Then connect them with the wonderful Belden Extension Floor Cord. It lies flat under the rug. Out of the way—no wiring—no fuss. Get one at your dealer, now!

Belden Mfg. Company
2312-A S. Western Avenue Chicago

Belden

CORWICO

Braidite

HOOK-UP WIRE
"THE BRAID SLIDES BACK"

Cuts Wiring Time in Half

Shove back the insulation, solder the connection and the braid slides back into place, leaving no exposed sections of bare wire. Braidite is the quickest and easiest working hook-up wire made.

Safe as insulated wire and as convenient as bare wire. You cannot scorch or burn Braidite with a soldering iron. Use Braidite in the next set you build.

At All Dealers

25 Feet Stranded 35c
25 Feet Solid..............30c

Red, Green, Yellow, Blue, Black.

FREE Send us the name and address of your dealer and we will send you a sample package of Braidite FREE. Include 10c for Postage.

CORNISH WIRE CO.
38 Church Street New York City

TROUBLE?

If your set or power pack refuses to work, or you want to improve the quality of reception or increase selectivity—

If you want to modernize and electrify your present receiver—

Let US help you solve your difficulty

For example: *It will cost you only from* $5.00 *to* $10.00 *for the repair service consisting of testing the receiver, tracing the trouble and then repairing it. The set will then be shipped to you in perfect operating condition and guaranteed.*

For further details address

SILVER RADIO LABORATORIES
2114 Mapes Ave. New York, N. Y.

Build a Daven Television Receiver

Complete Essential Kit, $60.00

THE first complete Kit. Furnished with either T-24, T-36 or T-48 Scanning Disk, Motor, Bushing, Rheostat, Daven Television Tube, 3 Complete Stages of Daven Television Amplification and Instructions for Building.

Daven Television Receiver, Complete, including Television Tube—$100.00 Less amplifier Tubes.

DAVEN TELEVISION APPARATUS

	Each
Daven Television Scanning Disks	
24 T-24	$ 5.00
36 T-36	7.50
48 T-48	10.00
Comb. Disc with 24, 36 and 48 Apertures T-468	15.00
Daven Tele. Amp. T-3	12.50
Daven Spec. Telev. Amp. T-4 for 2 Hi Mu Tubes and 2 power Tubes 171, 210, 250 Types	17.50
Daven Telev. Neon Lamp, 20 to 80 Milliamperes Striking Voltage 100 Plate 1½"x1½"	12.50
Daven Telev. Motor	27.50
Daven Bushing to fit ¼", 5/16 and ⅜" Motor Shafts	1.00
Daven Bushing for 48 Aperture disc	3.50
Daven Rheostat	3.50
Daven Telev. Photo Elect. Cell 1¾" Bulb	20.00
Daven Telev. Photo Elect. Cell 3" Bulb	37.50
Daven Television Couplers.	
1st Stage No. 421x D-421xx	
2nd Stage No. 422x D-422xx	
3rd Stage No. 423x D-423xx	
x Glastors are used for Grid and Plate resistors	2.15
xx Super Davohms in Plate and Glastors in Grid	4.65
Daven AC 71 for output tubes in series with Television Lamp	3.50
Daven AC 10 (for brighter illumination)	9.00
Daven Mu 20 Hi Mu Tubes for Amp. Stages	2.25
Daven Mu 6 Power Tube	3.50

Send 2c stamp for new Television Booklet

THE DAVEN CORPORATION
Amplification Specialists
190 Summit Street Newark, N. J.

$2.00 Insures Your A.C. Tubes

The Vitrohm 507-109 Unit costs $2.00. Installed on your radio set, it lengthens a. c. tube life by automatically lowering filament voltage.

Attached in a moment—Nothing combustible — Nothing to wear out—Does not get excessively hot.

It consists of a Vitrohm Resistor mounted within a perforated metal cage, a plug, and a receptacle.

Write for free information on this and other Ward Leonard Radio Products.

WARD LEONARD ELECTRIC CO. MOUNT VERNON NEW YORK

TOBE TRANSAFORMER AND "A" FILTER

Tobe TransAformer consists of a step down transformer and a 3 ampere rectifier unit completely assembled in one unit. Fits neatly on top of a Tobe "A" Filter as shown.

No wiring required, just plug into the house supply.

The Tobe "A" Filter and the Tobe TransAformer make a good, complete A Supply.

The same Tobe "A" Filter attached to any good two ampere charger such as a Tungar, Rectigon or even a good Electrollic charger, will make a complete A Supply.

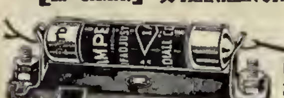
Tobe "A" Filter	$18.00
Tobe TransAformer	$15.00
Tobe A Supply includes Tobe "A" Filter and Tobe TransAformer, completely wired and assembled. 8 tube capacity	33.00

TOBE DEUTSCHMANN CO. *Canton, Massachusetts*

Your Tubes STEADY AS THE STARS *When AMPERITE-Controlled*

Don't let "A" battery current fluctuations spoil your radio reception or ruin your tubes. Install Amperites and *automatically* keep the filament temperature constant according to tube rating. Entirely unlike fixed resistors. With AMPERITE control tubes last longer and your set sounds better. Panel arrangement improved and wiring simplified. Tuning is easier and volume is increased. A type for every tube—battery or A. C.

[$1.10, with mounting (in U. S. A.) at all dealers.] *Radiall Company* 50 FRANKLIN ST., NEW YORK



FREE *"Amperite Blue Book" of latest circuits and construction data. Write Dept. RB 10*

AMPERITE REG. U. S. PAT. OFF.
The "SELF-ADJUSTING" *Rheostat*

Send For New Radio Book--It's Free

New hook-ups. This book shows how to make short wave receivers and short wave adapters. How to use the new screen grid tube in D. C. and A. C. circuits. How to build power amplifiers, ABC eliminators. Up-to-the-minute information on all new radio developments. It's free. Send for copy to-day.

KARAS ELECTRIC COMPANY
4033K2 N. Rockwell Street, Chicago

Name ....

St. and No..............................

City and State ....
4033K2

RADIO PANELS

BAKELITE—HARD RUBBER

Cut, drilled and engraved to order. Send rough sketch for estimate. Our complete Catalog on Panels, Tubes and Rods—all of genuine Bakelite or Hard Rubber—mailed on request.

STARRETT MFG. CO.
521 S. Green Street Chicago, Ill.

Send for WESTERN RADIO New 1929 Catalog

DEALERS AND SET BUILDERS

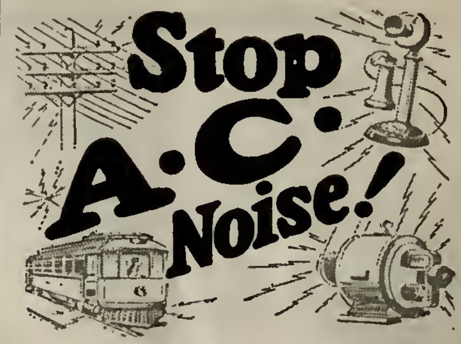
The NEW 1929 catalog is crammed full of the FINEST, NEWEST, Nationally known A. C. sets, consoles, cabinets, dynamic speakers, kits, eliminators and accessories at LOWEST PRICES. Largest stock of radio parts. Prompt delivery. *No delay.*

Write for our FREE catalog

WESTERN RADIO MANUFACTURING CO.
128 W. Lake St. *Dept. RB-10* Chicago

FREE

"The **Big Friendly Radio House"**



DON'T let the "static" that comes in over the house lighting system from motors, street cars, telephones and electrical appliances mar your radio programs with blare, squeal, fry and scratch! Plug in a Falck Claroceptor between wall socket and set and have clearer A.C. reception. A wonderful new improvement by a pioneer radio equipment manufacturer. Grounds and thus blocks out line interference noise and radio frequency disturbances. Also improves selectivity and distance. Requires no changes in set. Measures just 3½x5½x2½ inches. Tested, proved. Praised by thousands. Get one right away—at radio parts dealers. Write for descriptive folder.

$7.50 complete with cord and plug

Falck CLAROCEPTOR

Built by ADVANCE ELECTRIC CO.
1260 W. Second St. Los Angeles, Calif.
JOBBERS and DEALERS, GET OUR PROPOSITION

Be an EXPERT RADIO OPERATOR

MIDGET TELEPLEX

JUST LIKE HAVING AN EXPERT OPERATOR IN YOUR HOME

Only $3.50 Post-Paid

Good pay, travel, excitement, adventure. This wonderful instrument will teach you to read the code like an *expert* in half the usual time. Reproduces *actual sending* of expert operators. Sends messages, radiograms, newspaper matter, etc.—regular code traffic *anywhere, anytime* and at *any speed.* All you have to do is *listen.* Easy and fascinating. Strong, waxed tape-records carry complete code instructions. Just what you need for home practice. You'll be amazed when you hear it.

Satisfaction Guaranteed.—Send only $3.50 for MIDGET TELEPLEX with lessons, or $5.50 for complete set with high-frequency key and buzzer. *Satisfaction guaranteed.* Send Today.

TELEPLEX COMPANY
72 Cortlandt St., NEW YORK CITY

This is a good time to subscribe for RADIO BROADCAST
Through your dealer or direct, by the year only $4.00
DOUBLEDAY, DORAN & COMPANY, Inc., Garden City, N. Y.

SET BUILDERS

Write us for new illustrated Catalog "A-1" containing all the new and popular kits in radio. Our tremendous stock enables us to give you immediate service on all radio supplies at wholesale prices.

Allied Radio CORPORATION
711 W. LAKE STREET, CHICAGO

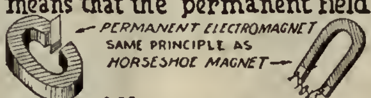
CROSLEY

DYNACONE

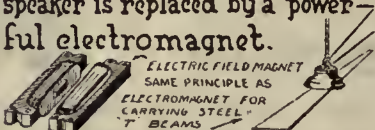
A simple explanation of the new, amazing power dynamic speaker that has swept the radio market at $25

The dynamic principle of radio speakers means *POWER*-combined with the finest attainable *QUALITY.*

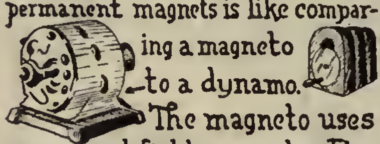
Dynamic speakers get their *POWER* by the use of an *electro-magnetic field.* Translated from Engineering into English this means that the permanent field



magnet of the average radio speaker is replaced by a powerful electromagnet.



Comparing the possible *POWER* of electromagnets and permanent magnets is like comparing a magneto to a dynamo.



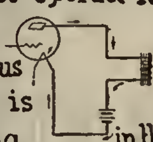
The magneto uses permanent field magnets. It will serve admirably as a shocking machine but cannot light a single lamp bulb.

The dynamo uses electro-magnets. Even a moderate sized dynamo will run the lights of an entire village.

Heretofore, the use of dynamic speakers was limited to a comparative few who could afford them because they required a separate battery to supply the current for their electromagnet coils.

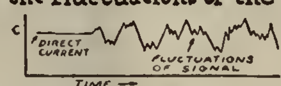
DYNACONE eliminates the battery

and utilizes current direct from the set to operate its field coils.



A continuous direct current is always flowing in the plate circuit of the power output tube of the radio set.

Upon this direct current is superimposed the fluctuations of the signal.

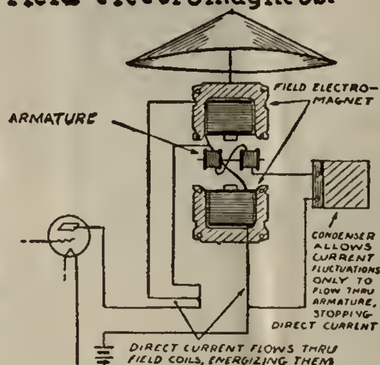


It has been customary to keep the direct current out of the loudspeaker because so strong a current would tend to *paralyze* the speaker by pulling its armature over against the field magnet.

To get rid of this strong direct current, a transformer,

or a condenser

is used, which allows only the signal fluctuations to enter the speaker armature. **DYNACONE** uses the latter method for keeping the direct current out of its armature but makes use of this very current, which other speakers throw away, for energizing its field electromagnets.



By thus ingeniously utilizing energy heretofore thrown away, **DYNACONE** achieves *POWER* and *QUALITY* only attainable with the dynamic principle, without any special batteries or other apparatus. It is simply connected directly in the output circuit of any set using a 171 type power tube operating at 180 volts on the plate.*

* If the set has an output transformer, this is disconnected by the dealer when DYNACONE is installed.

The above description applies to the Type E DYNACONE. The Type F DYNACONE, which has four connections to the set, takes its direct current from ahead of the output transformer instead of using a condenser to effect its separation from the voice current which actuates the armature.

THE CROSLEY RADIO CORPORATION
DEPARTMENT 20
Cincinnati, Ohio Powel Crosley, Jr., Pres.

Montana, Wyoming, Colorado, New Mexico and West prices slightly higher

MAGNAVOX "*Dynamic*" SPEAKERS

Belvedere Model

Two-tone walnut floor screen
For A-Battery Operation . . $50
For AC Operation $65

Beverly Model

Gracefully proportioned cabinet finished in light mahogany.
For A-Battery Operation $55
For AC Operation $70

Other floor and table models up to $175.
Units only; DC $35; AC $50.

"FIRST SPEAKER FIRST DYNAMIC"

DYNAMIC

First place in realism... extreme fidelity of reproduction... is accorded Magnavox Dynamic Speaker by fourteen makers of fine radio sets. They use it as built-in equipment to assure rich, undistorted reproduction, with great volume.

THE MAGNAVOX COMPANY

Oakland, California   Chicago, Illinois

THE COUNTRY LIFE PRESS, GARDEN CITY, NEW YORK